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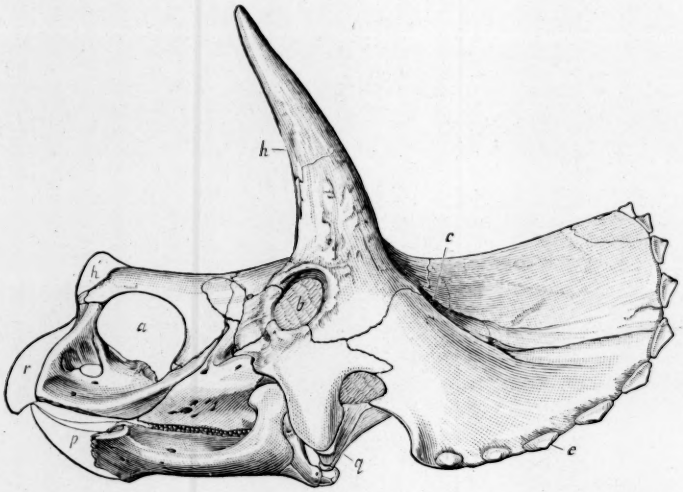

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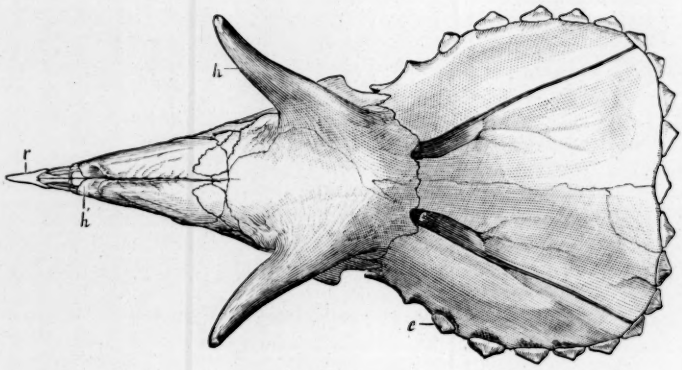

TRICERATOPS FLABELLATUS, Marsh. $\frac{1}{20}$ natural size.

FIG. 1.—The skull; seen from the side.

FIG. 2.—The same; seen from above.

a, nasal opening; *b*, orbit; *c*, supra-temporal fossa; *e*, epoccipital bone; *h*, frontal horn-core; *h'*, nasal horn-core; *p*, pre-dentary bone; *q*, quadrate; *r*, rostral bone.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE III. VOL. VII.

No. I.—JANUARY, 1890.

ORIGINAL ARTICLES.

I.—The Skull of the Gigantic Ceratopsidæ.[1]

By Prof. O. C. Marsh, Ph.D., LL.D., F.G.S.

(PLATE I.)

THE huge horned Dinosaurs, from the Cretaceous, recently described by the writer,[2] have now been investigated with some care, and much additional light has been thrown upon their structure and affinities. A large amount of new material has been secured, including several skulls, nearly complete, as well as various portions of the skeleton.

The geological deposits, also, in which their remains are found, have been carefully explored during the past season, and the known localities of importance examined by the writer, to ascertain what other fossils occur in them, and what were the special conditions which preserved so many relics of this unique fauna.

The geological horizon of these strange reptiles is a distinct one in the Upper Cretaceous, and has now been traced nearly eight hundred miles along the eastern flank of the Rocky Mountains. It is marked almost everywhere by remains of these reptiles, and hence the strata containing them may be called the Ceratops beds. They are freshwater or brackish deposits, which form a part of the so-called Laramie, but are below the uppermost beds referred to that group. In some places, at least, they rest upon marine beds which contain invertebrate fossils characteristic of the Fox Hills deposits.

The fossils associated with the *Ceratopsidæ* are mainly Dinosaurs, representing two or three orders, and several families. Plesiosaurs, Crocodiles and Turtles of Cretaceous types, and many smaller reptiles, have left their remains in the same deposits. Numerous small mammals, also of ancient types, a few birds, and many fishes, are likewise entombed in this formation. Invertebrate fossils and plants are not uncommon in the same horizon.

The *Ceratopsidæ*, as the most important of this assemblage, will be first described fully by the writer, under the auspices of the United States Geological Survey. In the present paper, the skull of one of these gigantic reptiles is briefly described, and figured, as a typical example of the group.

[1] Abstract of a paper read before the National Academy of Sciences, Philadelphia, November 14, 1889.

[2] American Journal of Science, vol. xxxvi. p. 477, December, 1888; vol. xxxvii. p. 334, April, 1889; and vol. xxxviii. p. 173, August, 1889.

The Skull.

The skull of *Triceratops*, the best known genus of the family, has many remarkable features. First of all its size, in the largest individuals, exceeds that of any land-animal, living or extinct, hitherto discovered, and is only surpassed by that of some of the Cetaceans. The skull represented in Plate I., the type of the species, is that of a comparatively young animal, but is about six feet in length. The type of *Triceratops horridus* was fully adult, and probably an old individual. The skull, when complete, must have been over eight feet in length. Two other skulls, both nearly perfect, now under examination by the writer, fully equal in bulk the two already described, and other similar specimens from the same horizon maintain equal average dimensions.

Another striking feature in the skull of this genus is its armature. This consisted of a sharp cutting beak in front, a strong horn on the nose, a pair of very large pointed horns on the top of the head, and a row of sharp projections around the margin of the posterior crest. All these had a horny covering of great strength and power. For offence or defence, they formed together an armour for the head as complete as any known. This armature dominated the skull, and in a great measure determined its form and structure.

The skull itself is wedge-shaped in form, especially when seen from above. The facial portion is very narrow, and much prolonged in front, as shown in Plate I. Fig. 2. In the frontal region, the skull is massive, and greatly strengthened to support the large and lofty horn-cores, which formed the central feature of the armature. The huge, expanded parietal crest, which overshadowed the back of the skull and neck, was evidently of secondary growth, a practical necessity for the attachment of the powerful ligaments and muscles that supported the head.

The front part of the skull shows a very high degree of specialization, and the lower jaws have been modified in connection with it. In front of the premaxillaries, there is a large massive bone, not before seen in any vertebrate, which has been called by the writer, the rostral bone (*os rostrale*). It covers the anterior margins of the premaxillaries, and its sharp inferior edge is continuous with their lower border. This bone is much compressed, and its surface very rugose, showing that it was covered with a strong horny beak. It is a dermal ossification, and corresponds to the pre-dentary bone below. The latter, in this genus, is also sharp and rugose, and likewise was protected by a strong horny covering. The two together closely resemble the beak of some of the turtles, and as a whole must have formed a most powerful weapon of offence.

In the skull figured on Plate I. the rostral bone was free, and was not secured. This was also true of the predentary bone, and the nasal horn-core. Hence these parts are represented in outline, taken from another specimen, in which they are present, and in good preservation.

The premaxillary bones are large, and much compressed transversely. Their inner surfaces are flat, and meet each other closely

on the median line. In old specimens, they are firmly coössified with each other, and with the rostral bone. They send upward a strong process to support the massive nasals. Another process, long and slender, extends upward and backward, forming a suture with the maxillary behind, and uniting in front with a descending branch of the nasal. The premaxillaries are much excavated externally for the narial aperture, and form its lower margin. They are entirely edentulous.

The maxillaries are thick, massive bones of moderate size, and subtriangular in outline when seen from the side. Their front margin is bounded mainly by the premaxillaries. They meet the pre-frontal and lachrymal above, and also the jugal. The alveolar border is narrow, and the teeth small, with only a single row in use at the same time. The teeth resemble, in general form, those of *Hadrosaurus*.

The nasal bones are large and massive, and greatly thickened anteriorly to support the nasal horn-core. In the skull figured on Plate I. these bones are separate, but in older individuals, they are firmly coössified with each other, and with the frontals. The nasal horn-core ossifies from a separate centre, but in adult animals it unites closely with the nasals, all traces of the connection being lost. It varies much in form in different species.

The frontals form the central region of the skull, and have been greatly strengthened to support the enormous horn-cores which tower above them. These elevations rest mainly on the frontal bones, but the supra-orbitals, the post-orbitals, and the post-frontals, have, apparently, all been absorbed by the frontals, to form the solid foundation for the horn-cores.

These horn-cores are hollow at the base, and in form, position, and external texture, agree closely with the corresponding parts of the *Bovidæ*. They vary much in shape and size in different species. They were evidently covered with massive pointed horns, forming most powerful and effective weapons.

The orbit is at the base of the horn-core, and is surrounded, especially above, by a very thick margin. It is oval in outline, and of moderate size. Its position and form are shown in Plate I. Figure 1 *b*.

The enormous posterior crest is formed mainly by the parietals, which meet the frontals immediately behind the horn-cores. The margin is protected by a series of special ossifications, which, in life, had a thick horny covering. These peculiar ossicles, which extend around the whole of the crest, may be called the epoccipital bones (Plate I. Figures 1 and 2, *e*). In old animals, they are firmly coössified with the bones on which they rest.

The lateral portions of the crest are formed by the squamosals, which meet the parietals in an open suture. Anteriorly, they join the frontal elements which form the base of the horn-core, and laterally, they unite with the jugal. The supra-temporal fossæ lie between the squamosals and the parietals, as shown on Plate I. Figure 2, *c*.

The base of the skull has been modified in conformity with its upper surface. The basi-occipital is especially massive, and strong at every point. The occipital condyle is very large, and its articular face, nearly spherical, indicating great freedom of motion. The basi-occipital processes are short and stout. The basi-pterygoid processes are longer, and less robust. The foramen magnum is very small, about one-half the diameter of the occipital condyle. The brain-cavity is especially diminutive, smaller in proportion to the skull, than in any other known reptile.

The exoccipitals are also robust, and firmly coössified with the basi-occipital. The supra-occipital is inclined forward, and its external surface is excavated into deep cavities. It is firmly coössified with the parietals above, and with the exoccipitals on the sides. The post-temporal fossæ are quite small.

The quadrate is robust, and its head much compressed. The latter is held firmly in a deep groove of the squamosal. The anterior wing of the quadrate is large and thin, and closely united with the broad blade of the pterygoid.

The quadrato-jugal is a solid, compressed bone, uniting the quadrate with the large descending process of the jugal. In the genus *Triceratops* the quadrato-jugal does not unite with the squamosal. In *Ceratops*, which includes some of the smaller, less specialized, forms of the family, the squamosal is firmly united to the quadrato-jugal by suture. Above this point it shows a number of elevations, which are wanting in *Triceratops*.

The quadrato-jugal arch in this group is strong, and curves upward, the jugal uniting with the maxillary, not at its posterior extremity, but at its upper surface, as shown in Plate I. Fig. 1 This greatly strengthens the centre of the skull which supports the horn-cores, and also tends to modify materially the elements of the palate below. The pterygoids, in addition to their strong union with the quadrate, send outward a branch which curves around the end of the maxillary. This virtually takes the place of the transverse bone. The latter is thus aborted, and is represented only by a small free ossicle resting upon the posterior extremity of the maxillary.

The lower jaw shows no specialization of great importance, with the exception of the pre-dentary bone already described. There is, however, a very massive coronoid process rising from the posterior part of the dentary, which is well shown in Plate I. Fig. 1. The articular, angular, and surangular bones, are all short and strong, and the splenial is comparatively slender. The angle of the lower jaw projects but little behind the quadrate.

The unique characters of the skull of the *Ceratopsidæ* are especially the following:—

(1) The presence of a rostral bone, and the modification of the pre-dentary to form a sharp, cutting beak.

(2) The frontal horn-cores, which form the central feature of the armature.

(3) The huge expanded parietal crest.

(4) The epoccipital bones.
(5) The aborted transverse bone.

These are all features not before seen in the *Dinosauria*, and show that the family is a very distinct one.

The peculiar armature of the skull has a parallel in the genus *Phrynosoma*, among the Lizards, and *Meiolania*, among the Turtles, and it is of special interest to find it also represented in the Dinosaurs, just before their extinction.

Such a high specialization of the skull, resulting in its enormous development, profoundly affected the rest of the skeleton. Precisely as the heavy armature dominated the skull, so the huge head gradually overbalanced the body, and must have led to its destruction. As the head increased in size to bear its armour, the neck first of all, then the fore limbs, and later the whole skeleton, was specially modified to support it.

These features will be discussed in a later communication, but to the present description of the skull should be added the fact that the anterior cervical vertebræ were firmly coössified with each other, an important character not before observed in Dinosaurs.

The skull represented on the accompanying Plate is the type specimen of *Triceratops flabellatus*, Marsh. It was found in the Ceratops beds of Wyoming by Mr. J. B. Hatcher, who also discovered the type of the genus *Ceratops*, in the same horizon in Montana.

II.—Did the Great Rivers of Siberia Flow Southwards and not Northwards in the Mammoth Age?[1]

By H. H. Howorth, Esq., M.P., etc.

THE question proposed in the heading to this paper seems a startling one. That the drainage of such a wide continental area as Northern Asia should have been entirely reversed at such a recent geological period as the Mammoth age, so that its present great drains, the Ob, the Yenissei and the Lena, did not exist at all, but their places were taken by other rivers pouring their waters, not into the Arctic basin, but into some great Mediterranean Sea in Central Asia, seems a paradox. It is nevertheless a conclusion which has been forcing itself upon me for a considerable time, and which I should like to be allowed to argue.

To begin with the current movement of the land in Northern Siberia, there can be no doubt whatever that the whole northern seaboard of the continent is rising rapidly from the water. Erman, Middendorff, and Wrangel, all diligent and careful explorers, are as one in regard to their lesson, which is that the northern part of Siberia, and, may I add, of Siberia in Europe also, that is to say, of the whole continent from the White Sea to Berings Straits, is rising from the sea. In a paper I wrote many years ago, which was published in the Journal of the Geographical Society, on Recent

[1] Full text of paper read in Section C (Geology) at the British Association, Newcastle-upon-Tyne, September, 1889.

Changes in Circumpolar Lands, I collected evidence of this fact, which is now an elementary postulate in physical geography.

That this rise has gone on for a long time is undoubted. It is equally undoubted that it has not gone on always, since we can measure the ultimate limit of the movement by the shells and other debris of the former tide-marks; the lines of shells, etc., found furthest south being a measure of the former extension southward of the Arctic Sea. What is plain is, that that sea has been shrinking, and is now shrinking very rapidly, and a great deal of what was under water and under ice not long ago is now dry land. This is universally admitted.

What is not so generally conceded, what in fact seems to have been entirely overlooked, is, that the result towards which this upheaval of the land and this shrinking of the Arctic Sea are tending was, in fact, reached during the Mammoth age, when it seems to be very certain, as I have tried to show in the GEOLOGICAL MAGAZINE, 1889, p. 305, that a large part of the Polar basin was occupied by land and not by water, that the level of the northern part of the great Siberian plain was very considerably higher, and that the period of submergence from which Northern Siberia is now escaping is a new feature, which followed upon a period of higher-level of the dry land in the Arctic region in the Mammoth age.

If the sea-bottom of the Arctic Ocean was sufficiently elevated to be laid bare over a large portion of the area east of Nova Zembla, there can be small doubt that the Western Siberian rivers could not flow in their present beds. The fall of these rivers is proverbially very slight, and it would be a good deal slighter if they had not carved furrows in which to flow, out of the tundras which they thread. So slight is their flow that in places they seem in a doubtful attitude as to whether they should run north or south. A few figures will be the best evidence of this. These figures I owe to my friend Mr. Ravenstein, who tells me they are absolutely and not merely barometrically correct, having been the result of a spirit-levelling operation carried out between 1875 and 1878. They refer to towns situated for the most part near the head-waters of the rivers in question or their feeders. Tobolsk 266 feet, Omsk 279 feet, Tomsk 302 feet, Krasnoyarsk 499 feet. The rivers Ob and Yenissei, however, have high banks, and have cut down their beds very deeply, so that we may take it that the real drop of these rivers from their upper reaches is certainly not more but probably considerably less than 250 to 300 feet.

Now the deepest known soundings in the eastern part of the Arctic Sea show a depth of about 25 fathoms, and inasmuch as recent Arctic shells have been found by Seebohm 500 feet above the present sea-level, this shows that since the Mammoth age the oscillation of level has been over 100 fathoms. An elevation of from 40 to 50 fathoms, however, operating along the Arctic borderland of Asia, would suffice to entirely reverse the drainage of the great rivers, which must in such a case have flowed southwards. This is a very curious induction, and seems inevitably to follow from

any postulate demanding a land-bridge between Siberia and America in the Mammoth age.

If the conclusion be sound, we ought to be able to apply an easy test to it, and to find abundant traces of the fact (if not, in the river-beds themselves, where the evidence might easily be obliterated), in the Central Asiatic area, for assuredly such a reversal of the flow of these enormous water-ways must have created an immense Mediterranean Sea in Central Asia.

Evidences of this sea are not only forthcoming, but they are so palpable and plain that it has become an axiom of physical geography that such a sea existed at no distant date. The proofs of it are various and converging. In the first place, the scattered lakes which dot this part of Asia from the Caspian to Lake Balkhash, whose common fauna can only be explained on the hypothesis that they are the fragments of a once continuous sheet of water, "Relikten seen" as the Germans call them, and secondly the great stretches of arid sand containing semi-fossil shells of species still living in the lakes referred to, and marked by saline deposits, sands known to the natives as the Karakum or black sands, Kizilkum or red sands, etc.[1]

Here then we get a double argument in favour of the contention I am arguing for. The *a priori* argument deducible from the effects of the rise of the Arctic sea-bed and the *a posteriori* argument deducible from the actual state of things in Central Asia, the latter being an argument universally conceded and hitherto needing only a rational explanation. While every one allows that a great sea once occupied the Aralo-Caspian depression, it has hitherto been a desideratum to know how this sea could have been supplied with its water, and how it resisted the desiccating effects of the Siberian climate, which are now so obvious. If, as we contend, the great rivers Obi and Yenissei at this date poured their waters into the Asiatic Mediterranean, the whole problem is explained.

I would add as a curious corollary, that the great plain of European Russia, which is in many ways a mere prolongation of Asia, and which was in the Mammoth age still more closely united with it in its physical characteristics, still retains its ancient slope, and its great rivers, the Volga, the Don, the Dnieper, and the Dniester still flow southwards. In the Mammoth age their waters were probably further recruited by that which goes to form the Petchora and the Neva. Apart from this last divergence, it seems rational to conclude that Eastern Europe at this moment presents a very close type of what Western Siberia once presented, and that the whole continent from the Caspian to the valley of the Yenissei then had a southern slope and was bounded on the south by a continuous sheet of water, of which the Black Sea and Lake Balkhash are the terminal relics.

I have limited my induction in regard to Asia to Western Siberia, but I have small doubt that what was true of the Obi and the Yenissei was true of the Lena also; but here the change that has since occurred in the contour of the country is greater and more complicated, and I will defer its discussion to another occasion.

[1] See S. P. Woodward, Manual of the Mollusca, p. 291, on the range of *Cardium rusticum*, *ibid.* Proc. Zool. Soc. July 8, 1856, part II.

The effects of this change of physical feature must obviously have been manifold. The existence of a great Central Asiatic Sea would greatly temper the Siberian climate, while the southern flow of its rivers would affect the distribution of animal and vegetable life, and offers at least a reasonable solution of the difficulties surrounding the migration of birds in the Palæarctic region, while it finally sweeps away the hypothesis that the Mammoth remains of Siberia are the wreckage of river portage.

III.—Note on the Classification of the Red Rocks in South-East Durham; and on a possible unconformity between the Trias and the Permian Limestone in the same District.

By H. H. Howell, F.G.S., etc,
Director of the Geological Survey of Scotland.

THE several bore-holes which have been put down through the Red Rocks in the south-east part of the county Durham to win the bed of Rock Salt there have directed attention to the age and classification of these rocks.

Mr. Edward Wilson in an exhaustive paper published in the Quarterly Journal of the Geological Society of London, has strongly supported the classification adopted and expressed on the maps of the Government Geological Survey of that district.

Mr. Howse, in the "Guide to the Collections of Local Fossils in the Museum of the Natural History Society, Newcastle-on-Tyne," recently issued, classes the whole of the Red Rocks down to and including the Salt-bed as Trias, but does not divide them into Upper and Lower divisions. He says, "It seems better to conclude that the red shales and sandstones at the mouth of the Tees represent a peculiar and local development of the Trias than attempt to split it up into divisions that have no exact representatives either in England or on the Continent."

Professor Lebour, formerly on the staff of the Geological Survey in Northumberland, in the "Handbook to the Geology and Natural History of Northumberland and Durham," which appears to be in part a re-issue (in the form of an "Official and Local Guide" prepared by him for the meeting of the British Association at Newcastle in 1889), of the second edition of his "Outlines of the Geology of Northumberland and Durham," published in 1886, gives his most recent views on the classification of the rocks between the Permian Magnesian Limestone and the Drift. He gives the following scheme merely as representing his own opinions derived from a careful examination of the evidence at present available on the subject:—

	Avicula contorta Beds	Rhætic.
	(Proved in Eston shaft and boring.)	
7.	Red and Green Marls with Gypsum (known only south of the Tees)	Upper Trias.
6.	Red Sandstone	
	Unconformity ??	
5.	Red Sandstones and Marls	Lower Trias.

Unconformity ? ?

4.	Red Marly Sandstones, Marls, with lenticular beds of Anhydrite, Gypsum, and Salt, and fœtid limestone in variable bands towards the base	Upper Permian (Rauchwacke).
3.	Thick Magnesian Limestone	Middle Permian.
2.	Marl Slate	
1.	Yellow Sands	Lower Permian.

Unconformity.

And further on, at p. 31, Professor Lebour criticizes the scheme adopted by the Geological Survey. I give the extract in full. He says, "When I first entered upon the study of this question, I was strongly prejudiced in favour of the view of the stratigraphical relations of these beds which is represented by the scheme according to which the maps of the Geological Survey are coloured, viz. :—

Rhætic.

Upper Trias (Keuper). { Red and Green Marl with Gypsum, 6 feet. Red and White Sandstone with bed of Red Marl, Gypsum and Rock Salt, 5 feet.

Permian.—Magnesian Limestone.

But there seems to be no good reason, in the total absence of fossils, for separating what I have called No. 4, into two divisions, the lower with and the upper without limestones. It is true that the reason for separating No. 5 from No. 4 is scarcely stronger, except that there is a distinct evidence that the former division now occupies a larger area than the latter, which is proof of overlap, if not of unconformity. There is also some, though less, evidence of No. 6 overlapping No. 5, or being unconformable to it, and there seems to be *absolutely nothing in favour of the assumption* that (whichever classification be adopted) the Triassic Series is in South Durham only represented by the Keuper."

As I was District Surveyor in charge of the Geological Survey of that district, and to some extent responsible for the classification adopted and expressed in the maps of the Geological Survey, I may be permitted to explain the reasons which induced me to recommend that the whole of the red rocks lying between the Rhætics and the Durham Permian Limestone should be classed as Trias, and as belonging to the Upper or Keuper division of that formation.

Now the position of the Rhætic beds on the Yorkshire side of the Tees is well known, and beneath them there is something like from 400 to 500 feet of Red Marls—the Keuper Marls—which graduate down into Sandstones with beds of Red Marl—the Lower Keuper Sandstones or Waterstones—of other districts in Britain. Down to this horizon I believe all are agreed—there is no difference of opinion—that these strata belong to the Keuper division of the Trias.

But in this district beneath these undoubted Keuper beds, there is a great—an abnormal thickness of sandstones, sandy marls, and marly sandstones, with thick deposits of gypsum and anhydrite at their base, with which the bed of Rock Salt is associated, which cannot be very well correlated with other districts.

When I was engaged on the Geological Survey there, the difficulty presented itself to me as to what these red rocks should

be called, and it was not neglected. Any one who will look at the Drift editions of the Geological Survey maps will see at a glance that the whole of the low-lying district bordering on the Tees in S.E. Durham and North Yorkshire is covered by an almost unbroken sheet of Glacial Drift and alluvial deposits which mask the underlying solid rocks; therefore sections of the red rocks exposed at the surface are few and far between. They are visible at Seaton Carew, and up the Tees at Coatham Stob, Dinsdale, Hurworth, and Croft. I examined all these sections, and it was my opinion then and it is my opinion now that the rocks have a distinctly Keuper aspect. They are not in the least like the Bunter—the soft upper and lower brick red sandstones with intervening pebble beds, which I mapped in my younger days in the Midland Counties, and which I was taught to regard as Bunter. I have also examined the cores of these rocks brought up at several bore-holes, and they tend to confirm me in this opinion. Neither could I find any trace of a physical break or unconformity within these red rocks—they seemed to be due to one continuous deposition. In the face of this evidence it does seem to me that it would have been absurd to split up the red rocks into divisions and draw hypothetical lines separating Keuper Sandstones and Marls from Bunter Sandstones and Marls, and Bunter Sandstones and Marls from Permian marly Sandstones and Marls. Therefore, I felt compelled to carry the base-line down to an horizon where the lithological characters were marked and distinct, viz. to the junction of the red rocks with the Durham Permian Limestone. And there is also at this horizon, I think, some evidence of a possible unconformity. I use the word "possible" advisedly, because I am not very sure that the position of the Triassic rock on the Permian Limestone may not be explained in another way. But the evidence for the unconformity, such as it is, is this. At the Seaton Carew bore-hole, I think it has been undoubtedly proved that the red rocks with gypsum and anhydrite at their base rest upon the upper division of the Durham Permian Limestone—that division which comes to the surface in the cliffs at Hartlepool and at other places along the Durham coast. The stratigraphical position of this division is from 700 to 800 feet above the Marl Slate. Then again in the flat country bordering upon the estuary of the Tees numerous bore-holes have been put down through the red rocks to work the salt-bed there, and some of these borings have been carried down into limestones beneath the salt-bed. It has been stated more than once that these limestones were not fossiliferous, and could not be identified with any beds coming to the surface at the outcrop. As regards one bore-hole this is most certainly a mistake. I refer to the one which was put down for the Newcastle Chemical Company on reclaimed land on the north side of the Tees opposite Middlesborough. I was consulted about this boring from the first, therefore I am well acquainted with it. The section of the red rocks passed through agreed very closely with that of neighbouring bore-holes, with the exception of the absence

of the salt-bed, which was unfortunate commercially, but does not materially affect the question under discussion.

I recollect very well when resident at Darlington, Mr. Wilton Allhusen bringing me a portion of the first core of limestone which had been bored through, and asking my opinion whether the horizon of the salt-bed had been passed, and whether there was any prospect of success by continuing the bore-hole deeper into the limestone.

I told him the fact of reaching the limestone after passing through the red rocks without finding the salt-bed proved the latter to be absent, and that there would be no prospect of success by going deeper into the limestone. But Mr. Alfred Allhusen was more sanguine, and the boring was continued to a greater depth. The result was that no salt-bed was found, but some very interesting cores of limestone were brought up.

I examined these cores, and on one occasion I was accompanied by Mr. Howse, Curator of the Museum of Natural History, Newcastle-on-Tyne, and Dr. Veitch, of Middlesborough. Mr. Howse saw that the limestone was fossiliferous, and his well-trained eye at once detected the small *Axinus* (*Axinus dubius*), and it was also noted that a roestone bed similar to one which occurs in the limestone forming the cliffs at Hartlepool had been passed through. Here then I think there is undoubted proof that the red rocks rest upon the uppermost division of the Durham Permian, as at Seaton Carew.

I now wish to direct attention to the western outcrop of the red rocks in the neighbourhood of Darlington, Leeming Lane (where the Vale of Mowbray Brewery is situate), and Ripon. There we have sandstone and marls underlaid by thick deposits of gypsum (as much as 40 feet was proved at the well at the Vale of Mowbray Brewery), which in turn rest directly upon the Permian Limestone. Here, however, they rest, not upon the upper division—the Hartlepool beds—but upon the fossiliferous and compact limestone zone of the Durham Permian—that division which immediately overlies the Marl Slate. It is on these grounds that I think there is some evidence of an unconformity, and that the red rocks may be transgressive over the various divisions of the Durham Permian Limestone from Hartlepool to Darlington and Leeming Lane.

I may add a word upon the lowest set of beds—limestones, and marls with gypsum and rock salt (14 ft.)—proved in the trial bore-hole of Messrs. Bell Brothers at Saltholme beneath the main bed of rock-salt.

The late Director-General of the Geological Survey, Professor (now Sir Andrew) Ramsay, in his Presidential Address to the British Association at the meeting at Swansea in 1880, refers to this lowest set of beds, and claims the 14 feet bed of rock-salt proved beneath the limestone to be of Permian age. He says, "In the North of England, at and near Middlesborough, two deep bore-holes were made some years ago in the hope of reaching the Coal-measures of the Durham Coal-field. One of them at Saltholme was sunk to a depth of 1355 feet. First they passed through

74 feet of superficial clay and gravel, next through about 1175 feet of Red Sandstones and Marls with beds of rock-salt and gypsum. The whole of these strata (excepting the clay and gravel) evidently belong to the Keuper Marls and Sandstones of the upper part of our New Red series. Beneath these they passed through 67 feet of dolomitic limestone, which in this neighbourhood forms the upper part of the Permian series, and beneath the limestone the strata consist of 27 feet of gypsum and rock-salt and marls, one of the beds of rock-salt having a thickness of 14 feet. This bed of Permian Salt is of some importance, since I have been convinced for long that the British Permian strata were deposited, not in the sea, but in salt lakes comparable in some respects to the Great Salt Lake of Utah, and in its restricted fauna to the far greater salt lake of the Caspian Sea."

I do not think the late Director-General ever saw the cores of the strata passed through in the Saltholme boring, but I examined them, and I think he must have formed his opinion from the recorded section and my description of them, and also from analyses of two samples of the limestones, one taken from the bed at the depth of 1261 feet, and the other at a depth of 1320 feet. These analyses were kindly given to me by Mr. T. Hugh Bell for the use of the Geological Survey, and I showed them to the late Director-General who visited me in his official capacity when I was resident in Darlington.

Mr. Edward Wilson is not inclined to admit the Permian age of these "limestones" and the salt-bed which has been proved beneath them. He demurs to the use of the term "limestone" as applied to the whole of these beds, and designates them instead "indurated marls." He adds, "Although there appear to be dolomitic or calcareous, as well as dark bituminous beds among them, they show no sort of resemblance to any known beds of the Magnesian Limestone of Durham; on the other hand, they possess the characteristic greenish colour of certain Keuper Marls, as well as a similar texture, and probably also mineral composition, although decidedly harder than most of the rock of that series." On these grounds Mr. Wilson classes these strata with the Keuper division of the Trias.

I append the analyses, of what I believe to be fair samples of the strata bored through at the depths above mentioned, and they seem to me to be something more than "indurated marls."

Sample of Magnesian Limestone from the bore-hole (Saltholme), 1261 feet:—

Carbonate of lime	54·71
,, ,, magnesia	41·18
,, ,, iron	·81
Silica	2·00
Alumina	trace
Water	1·08
Bitumen	·22
	100·00

Limestone from the bore-hole, underlying the Magnesian Limestone, sample 1320 ft. depth :—

Carbonate of lime	94·48
,, ,, magnesia	2·98
,, ,, iron	·78
Silica	1·20
Alumina	0·20
Bituminous matter	·36
	100·00

Mr. Howse in a paper entitled a "Note on the South Durham Salt Borings, with remarks on the Fossils found in the Magnesian-Limestone Cores, and the Geological Position of the Salt,"[1] of which he has kindly sent me a copy, discusses the age of the limestones and underlying salt-bed and marls at the Saltholme boring. He strongly supports the view that they are of Permian age. He examined the cores soon after the boring was completed, and "came to the conclusion that this limestone and marl were identical with the Upper Limestone and Red Marl of Sedgwick, the Brotherton Beds, and Red Marl of Kirkby, as exposed at Knottingly, Brotherton, and other places in the south of Yorkshire; and that it was also identical with the 'Plattendolomit' of Geinitz, as seen near Gera, in the outskirts of the Thuringerwald, and many other parts of Germany."

IV.—Coal in the South East of England.

By W. Whitaker, B.A., F.R.S., F.G.S.

"WITH regard to the probability of coal under cretaceous rocks in the South of England it seems hardly possible to conceive that the commercial enterprise of Englishmen could have failed to discover it long ago if it had been in existence."

The above quotation, from a Presidential Address, by Mr. H. Hall,[2] might serve as the text for a short discourse on the commercially unenterprising character of one's fellow-countrymen, who have done practically nothing in the matter!

A deep trial-boring was certainly made some years ago, near Battle: but the Sub-Wealden Boring was not a matter of commercial enterprise. Other deep borings have also been made in the South of England, which partake more of the character of work referred to, though only as regards the getting of water, not the least idea of looking for coal having influenced those who made them. It is indeed to the enterprise of corporations, of companies, and of Government, in the search for water, that we owe almost all our direct knowledge of the rocks underlying the Cretaceous beds of the London Basin.

Just one trial-boring is being made in search for coal, strange to say by a Railway Company; but, though extraordinary rumours

[1] Natural History Transactions of Northumberland, Durham, and Newcastle-on-Tyne, vol. x. part ii.

[2] Trans. Manchester Geol. Soc. vol. xx. p. 388, and earlier in various weekly newspapers.

now and then come from Dover, practically nothing is known, beyond the very small circle of the highly privileged few, of what has been found there. Since the above was written however a welcome announcement has appeared that Prof. Boyd Dawkins hopes before long to let anxious geologists know something about the matter. May he have something fresh to tell us![1]

As a geologist I must decline to be in any way bound by the lamentable failure, or one may say the heartrending absence, of commercial enterprise amongst my fellow-Englishmen. I have elsewhere given a lengthy account of what has been published on the subject of the old underground rocks of the London Basin, and, in summing up the general conclusions that, to my mind, may fairly be drawn, as to the possible occurrence of Coal Measures, have ventured to say, "it seems to me that *the day will come when coal will be worked in the South East of England.*"[2]

I am glad to say, however, that there is now an opening for the development of enterprise in the scientific investigation of the deep-seated geology of south-eastern England. Mr. J. T. Day, F.G.S., impressed with the importance of the question, "Is there Coal under the London Basin?" has issued a circular, from which the following extracts are taken:—

"This question has frequently been asked, but no systematic attempt has ever been made to answer it."

"If it should be found that coal does exist at workable depths, and within easy reach of the metropolis, the value of the discovery . . . would be enormous."

"With the view, therefore, to a systematic investigation of the matter, it is proposed to raise a fund of 2000 guineas to meet the cost [of trial-boring]. This fund will be presided over . . . by a committee to be selected from amongst the subscribers."

"Promises of support . . . should be sent to . . . J. T. D," [12, Albert Square, Stepney, London, E.].

Cash is not asked for, only promises, to be redeemed when a settled plan has been arrived at. Presumably before starting any work a strong committee of experts would be consulted, and it should be mentioned that both Prof. Prestwich and Prof. Judd are in favour of the scheme.

All those who take an interest in the question should communicate with Mr. Day, who wishes it to be understood that his proposal is not put forward on commercial grounds, although it appeals to commercial instincts as well as to the wish for further knowledge in a very important matter.

Such being the state of the case, I am anxiously awaiting the appearance of "commercial enterprise," coupled with scientific inquiry.

[1] Trans. Manchester Geol. Soc. vol. xx. p. 352.

[2] The Geology of London, etc., vol. i. p. 46 (1889). Reviewed in Geol. Mag. Dec. 1889, p. 568.

V.—Notes on the Devonian Fishes of Scaumenac Bay and Campbelltown in Canada.[1]

By Dr. R. H. Traquair, F.R.S., F.G.S.

THE researches of the officers of the Geological Survey of Canada have brought to light, in the Devonian rocks of Scaumenac Bay and of Campbelltown, a series of fossil fishes which are of especial interest to the geologist as well as to the zoologist, on account of the analogies which they bear to the fishes of the Old Red Sandstone of Great Britain. Principally collected by Mr. G. H. Foord, these fishes have been described by Mr. J. F. Whiteaves,[2] and are indeed remarkable for their beautiful state of preservation, which enables them to throw fresh light on many points in the structure of these ancient forms. From a purely geological standpoint their interest is not less, as we shall see.

The Edinburgh Museum having been fortunate enough to obtain a valuable collection of these fishes, I am enabled to supplement Mr. Whiteaves's descriptions, as well as to add at least two additional species to the list.

I. Fishes from the Upper Devonian of Scaumenac Bay.

Ctenodontidæ.

Phaneropleuron curtum, Whiteaves.—As Mr. Whiteaves points out, this species is distinguished emphatically from the Scotch *Ph. Andersoni* by its comparatively short and deep outline, which in this case is certainly not due to distortion. Some of the Edinburgh specimens show the Ctenodont dentition very clearly, but in no case have I seen the "smooth, conical and somewhat compressed teeth," which Mr. Whiteaves mentions as arming both the upper and under jaw. And here I must make an important correction. In his second quarto memoir (1889) Mr. Whiteaves refers to a fragment collected by Mr. Foord in 1881, in which the eye is situated very far forwards and surrounded by a complete circle of about 26 circumorbital plates. Referring also to the suborbitals and preoperculum, which are also shown in the specimen, he says that they are "exactly similar to the corresponding plates in *Eusthenopteron*." Now, if we refer to the figure given of this specimen (ib. pl. x. fig. 1), it will be seen that this exact similarity is shared also by the anterior half of the cranial buckler which is present, as well as by the maxilla, and the jugular plate. Moreover, the orbit does not occupy that position in *Phaneropleuron curtum;* for according to a specimen now before me, it is placed, as in *Ph. Andersoni*,[3] comparatively far back, and not much in front of the

[1] Read before Section C of the British Association at Newcastle-on-Tyne, September 16th, 1889.

[2] Am. Journ. Sc. and Arts (3), xx. 1880; Canad. Naturalist, n. ser. x.; Am. Naturalist, xix. 1885; Canad. Nat. and Quart. Journ. Sc. n.s. vol. x. 1881. Mr. Whiteaves's detailed descriptions are given in two quarto memoirs entitled "Illustrations of the Fossil Fishes of Canada," from the Trans. Roy. Soc. Canada, vol. iv. sec. iv. 1886, and vol. vi. sec. iv. 1888.

[3] On the position of the orbit in *Phaneropleuron Andersoni* see Traquair, Geol. Mag. Vol. VIII. 1871, pp. 530-531.

operculum. In fact, there can be no doubt that the specimen referred to by Mr. Whiteaves belongs to *Eusthenopteron Foordii*, and not to *Phaneropleuron* at all. The "circumorbital" plates are, as we shall see under *Eusthenopteron*, sclerotic in their nature.

PTERICHTHYIDÆ.

Bothriolepis Canadensis, Whiteaves.—Remarks on this species will be found in my paper on the "Structure and Classification of the Asterolepidæ," Ann. and Mag. Nat. Hist. for Dec. 1888.

CEPHALASPIDÆ.

Cephalaspis laticeps, sp. nov.—Only one specimen, which shows the cranial shield, with badly-preserved traces of the body. Shield proportionately rather broad, length $1\frac{3}{8}$ inch, breadth $2\frac{3}{4}$ inches, cornua short: orbits rather close together, oval, large: tesselated divisions of middle layer very small: external surface ornamented by small, smooth, polished and rounded tubercles, moderately close in position.

This is the first occurrence of a Cephalaspid in rocks of later age than the Lower Devonian, and as such is worthy of the attention of the geologist.

ACANTHODIDÆ.

Acanthodes concinnus, Whiteaves.—This is a true *Acanthodes*, and differs remarkably in the sculpture of the scales from all the other species of the genus.

Mesacanthus affinis, Whiteaves, sp.—At first Mr. Whiteaves was inclined, though doubtfully, to refer this little fish to *Acanthodes Mitchelli* of Egerton, from the Forfarshire beds; subsequently, however, he decided to retain it as distinct, though still apparently with doubt, as he speaks only of there being "some reason for supposing that this interesting little fish is distinct from the *A. Mitchelli* of the Devonian rocks of Scotland." It is, however, only necessary to place specimens of the two forms side by side to see that they are quite distinct, as the scales of the Canadian species are proportionally very much larger than in *Mitchelli*.

Owing to the very distinct presence of a pair of small spines intermediate between the pectorals and ventrals in *A. Mitchelli*, and in *A. Peachii*, Eg., I have proposed to include them in the new genus *Mesacanthus*,[1] including also, from its general aspect, *A. pusillus*, Ag., from the Moray Firth beds, although our specimens of the latter are not well enough preserved to show them. Here I would also place *M. affinis*, as in one specimen I at least imagine I see one of those minute intermediate spines.

HOLOPTYCHIIDÆ.

Glyptolepis Quebecensis, Whiteaves.—The collection in the Edinburgh Museum contains one head of a small Holoptychian fish which I provisionally refer to this species, although unfortunately no body is present: equally unfortunately, the head in the only specimen described by Mr. Whiteaves is not well enough preserved to show

[1] GEOL. MAG. Dec. III. Vol. V. 1888, p. 511.

its structure or markings. This head displays the typical Holoptychian osteology and dentition, the laniaries of the under jaw being acutely conical, and striated to near the apex: they seem, however, to be round in transverse section.

Mr. Whiteaves at first referred his *Glyptolepis* to *G. microlepidotus* of Agassiz, though with some doubt, and even in his subsequent detailed description, in which he adopts the name *Quebecensis*, he still seems to be uncertain as to its distinctness or the contrary. For he says: "As it seems impossible to decide from the description and figure of *G. microlepidotus* in Agassiz's monograph whether the Canadian species is identical with it or not, it seems safer to give the latter a provisional name until the true specific relations of each shall have been ascertained by a direct comparison of specimens from both sides of the Atlantic."

There is, however, no need for regarding the name *Quebecensis* as provisional, so far as any possible identity with *microlepidotus* is concerned. For Mr. Whiteaves's figure shows a true *Holoptychian*, and *probably* a *Glyptolepis*, whereas Agassiz's *G. microlepidotus* is not referable to *Glyptolepis* at all, nor even to the same family. That fish is, as I have shown (Geol. Mag. Dec. III. Vol. V. 1888, p. 514), a true Rhizodont, and is, I believe, both generically and specifically identical with McCoy's *Gyroptychius angustus*.

Rhizodontidæ.

Eusthenopteron Foordii, Whiteaves.—The characters which Mr. Whiteaves gives as distinguishing his genus *Eusthenopteron* from *Tristichopterus*, Egerton, are briefly as follows:—

1. That "the vertebral centra of *Eusthenopteron* do not seem to to have been ossified at all," whereas "in *Tristichopterus* on the other hand the vertebral centres are stated to be completely ossified."

2. That the large bones bearing the three ossicles which directly support the second dorsal and the anal fin in *Eusthenopteron* are interspinous in character, whereas "the corresponding bones in *Tristichopterus* are represented as spinous rather than interspinous in their character, and as each abutting directly on the vertebral axis."

3. The much greater vertical symmetry of the caudal fin in *Eusthenopteron*.

4. The presence of two cutting edges in the laniary teeth of *Eusthenopteron*.

Reasons 3 and 4 certainly hold good whether they be of generic value or not. But such is not the case with the first and second. For specimens of *Eusthenopteron Foordii* now before me show undoubtedly the presence of vertebral centra in the anterior part of the body at least, these being in the form of hollow rings as in *Rhizodopsis*, and I am firmly of opinion that the vertebræ of *Tristichopterus* are in the same condition, and that "in this genus the ossification and segmentation of the vertebral column" was *not* "complete," as supposed by Sir Philip Egerton. And also as regards the large fin-supporting bones alluded to in the second reason, I am equally of opinion that Sir Philip Egerton was in error in consider-

ing them to be spinous, and not interspinous. It would indeed be odd if so great a morphological difference existed between such similar elements in such closely-allied fishes. Comparing specimens of *Eusthenopteron* and *Tristichopterus* in the Edinburgh collection, there can be no doubt as to their *exceeding* similarity of structure, though the differences mentioned in reasons 3 and 4 seem to me to justify the retention of the former generic name. It must be remembered, however, that in such questions much depends on the idiosyncracy of the individual writer—differences, which to some minds may seem generic, are not always of the same importance in the eyes of others.

Mr. Whiteaves describes the cranial buckler as divided by a transverse suture into two unequal parts, an anterior or *frontal*, and a posterior or *parietal* plate. This is of course true, but he makes no mention of the constituent bones of these two great divisions of the cranial shield, which can, in fact, only be made out when the shield is viewed from the internal or non-sculptured aspect. The posterior part may be seen in this way to consist of two elongated parietals, each of which is flanked by two smaller plates, a squamosal behind and a postfrontal in front, exactly as in *Rhizodopsis*, *Osteolepis*, etc. Likewise the anterior portion consists of two frontals in contact with each other in the middle line, but without the pineal foramen seen in many Osteolepids (*Osteolepis*, *Diplopterus*, *Thursius*), while in front of these, and received posteriorly in an angle between their anterior extremities is an oblong median ethmoidal, flanked on each side by a lateral ethmoidal, while the space between these and the premaxillæ is apparently covered by a number of small polygonal plates as in Holoptychids, Rhizodonts, and Osteolepids generally. I have remarked above that the sutures between these plates can only be seen when the cranial shield is examined from the internal aspect; on the outside nothing is seen but a median groove, noticed by Whiteaves, separating the two frontals, and bifurcating in front behind the median ethmoid.

A circle of small quadrangular or slightly wedge-shaped plates occurs in the position of the eye, of which six are seen in one specimen before me, while in Mr. Whiteaves's paper five are represented in his restored figure (pl. vi. of his second quarto paper), and the whole circle, "about twenty-six," in the specimen erroneously referred to *Phaneropleuron* (*ib.* pl. x. fig. 1). Of these plates Mr. Whiteaves observes that they "are probably homologous with the circumorbitals of Traquair's restoration of *Dapedius*, as well as suggestive in a general way of the still more highly specialized sclerotic plates in the eye of *Ichthyosaurus* and *Megalosaurus*."

Now, as it is clear that these little plates cannot be both of two such very different things at once, a choice must be made, and from their shape and their position relative to the other bones in the head in which I have observed them, I have no doubt that they are sclerotic and not circumorbital in their nature. If this view be correct, we have in *Eusthenopteron* a condition almost unique among fishes, for though sclerotic ossifications are not uncommon amongst them, in no fish except certain Cœlacanths do they assume the form

of a continuous ring of quadrangular plates as they do in recent Birds and Lizards and in extinct Ichthyosauria and Stegocephala.

The plate labelled "preoperculum" by Whiteaves consists in reality of three pieces, as in *Rhizodopsis*, *Megalichthys*, etc., of which only one, the narrow semilunar posterior division (see my figure of the head of *Rhizodopsis*),[1] can be supposed to represent a preoperculum, the other two being cheek-plates. Here I must confess to have also failed to observe this in my previous study of *Tristichopterus*,[2] as a re-examination of the same specimens incontestably proves the presence of the same elements in that genus.

The mandible shows very distinct evidence of being composed of the same elements as in *Rhizodopsis* and *Rhizodus*. The laniary teeth are like those of *Rhizodus* in miniature, being rounded and fluted at the base, smooth and two-edged higher up. A transverse section of the fluted portion shows that the dentine is here thrown into complex labyrinthine foldings. I can see none but small teeth on the maxilla, as in other Rhizodonts and Osteolepids, but the vomers are, as usual, armed with strong tusks. Mr. Whiteaves states that "in *Eusthenopteron*, as in *Tristichopterus*, no trace can be detected of an azygos jugular plate, or of any small lateral plates." There is certainly no median jugular, but in one of our specimens the presence of five narrow lateral jugulars is very distinctly shown. No specimen of *Tristichopterus* as yet known is well enough preserved in this region to show these small lateral plates.

A very great interest attaches to the internal skeleton of the paired fins, which in the case of the pectoral is tolerably accurately figured by Mr. Whiteaves, though he does not seem very decided as to the interpretation to be placed upon the arrangement shown. There is a segmented axis consisting of four bony segments or mesomeres, placed end to end, each being slightly constricted in the middle. Each of these, except the last, has likewise attached to it on the preaxial side of its distal extremity, a small bone, also constricted in the middle and passing outwards and backwards at an acute angle; these small bones being clearly parameres. The first mesomere, and in one case also the third, gives off likewise on its postaxial side a flat backwardly directed process, which is certainly only a process and not a distinct bone. I may here also state that there is some evidence of an additional mesomere in advance of or proximally situated to that which I have termed the first, and bearing no paramere. A very similar arrangement is found in the pelvic fin, whose internal skeleton was not perfectly preserved in Mr. Whiteaves's specimens; here I find at least two mesomeres, each bearing a paramere, there being, I think, also a probability of the presence of a third or distal mesomere.

The arrangement seen in the pectoral fin of *Tristichopterus*, which I figured in 1874,[3] is essentially the same as that described above, though at the time I wrote my description of the last-mentioned genus, and taking the condition of preservation of the specimen into

[1] Trans. Roy. Soc. Edin. vol. xxx. 1881.
[2] Trans. Roy. Soc. Edin. vol. xxvii. 1874.
[3] Trans. Roy. Soc. Edin. pl. xxxii. fig. 9.

account, I did not feel quite certain as to whether I should consider the postaxial processes of certain mesomeres as parameres or not. The internal skeleton of the pectoral in the Carboniferous *Rhizodopsis*, as I have observed it in specimens belonging to Mr. Ward, F.G.S., of Longton, is also constructed on the very same plan.

It follows, then, that the skeleton of the paired fins in the Rhizodontidæ is an abbreviate uniserial "archipterygium," and if, as seems probable, the Holoptychiidæ are the more archaic group, then the Ceratodus-like pectoral of *Holoptychius* is a more primitive form of limb. This paired-fin skeleton in *Eusthenopteron* and its allies may therefore, along with the corresponding conditions in *Pleuracanthus* and *Cladodus*, be considered of special interest in connection with the "archipterygium question."

PALÆONISCIDÆ.

Cheirolepis Canadensis, Whiteaves.—Unfortunately the Edinburgh Museum contains only a few fragments of this species, so that I have no means of comparing it thoroughly with the Scottish specimens of the genus, all of which, in my opinion, are referable to *one* species only, *Ch. Trailli*, Ag.

II. *Fishes from the Lower Devonian of Campbelltown.*

COCCOSTEIDÆ.

Phlyctænius, nov. gen. *Ph. Acadicus*, Whiteaves, sp.—On examining several pretty good specimens of this curious Coccostean, named by Mr. Whiteaves *Coccosteus Acadicus*, I find that it exhibits certain characters which are neither in accordance with those of the genus *Coccosteus*, nor with Mr. Whiteaves's diagram of its cranial shield. Allied to *Coccosteus* it is, as the arrangement of the sensory grooves, correctly indicated in Mr. Whiteaves's figure, clearly shows. But the sutures between the bones are only seen with the greatest difficulty; indeed Mr. Whiteaves admits that the dotted lines in his figure only represent their "supposed outlines." Accordingly he has indicated by means of those dotted lines certain plates having the same general outline as the median-occipital, lateral-occipital, and central plates in *Coccosteus decipiens*, Ag., whereas the real outline of these plates seems to me to be very different. The median-occipital, instead of being trapezoidal, with long posterior margin, shorter anterior one, and convergent sides, appears elongated and five-sided, there being an anterior acute angle which is received in a notch between the two centrals in front, which are themselves also elongated and more or less of a six-sided contour. Laterally the external occipital, marginal, and postorbital may be easily made out, and I think the preorbitals are also apparent enough. The orbital portion of the shield (= the part between the letters *d* and *e* in Whiteaves' figure) are rather more anterior and look more forwards than in *Coccosteus*. None of our specimens show Mr. Whiteaves's "rostral" plate, which is evidently the equivalent of that which I have called anterior ethmoidal in *Coccosteus decipiens*.[1]

[1] *Homosteus* compared with *Coccosteus*, GEOL. MAG. Dec. III. Vol. VI. Jan. 1889, Pl. I. Fig. 2 *a*, *e*.

The difference in the form of those bones of the cranial shield seems to me certainly to be of generic importance, and I doubt not but that many other important differences would be apparent were the remains more complete. (I may remark that the plate figured by Mr. Whiteaves as a "ventro-median (?) plate" cannot be so, as it is not bilaterally symmetrical.) I therefore propose for it the generic name *Phlyctænius*.

It is also of considerable interest to note that the Edinburgh Museum also possesses a small Coccostean head from Cradley, Herefordshire, which is referable to the same genus as the above. A description of this, the first known Coccostean from the West of England, is reserved for the next Number of the GEOLOGICAL MAGAZINE.

CEPHALASPIDÆ.

Cephalaspis Campbelltownensis, Whiteaves.—Mr. Whiteaves mentions as a character of this species that the surface displays little pits instead of the characteristic tuberculation. The outer surface does not seem to me to be preserved in the Campbelltown Cephalaspidæ any more than it is in those from some localities in Forfarshire.

In its contour the shield of *C. Campbelltownensis* is, however, proportionally considerably broader than in *C. Lyelli*, though this may partly be due to these shields in the Campbelltown deposits being always crushed out quite flat. The orbits are proportionally further back from the front of the shield.

Cephalaspis Whiteavesi, sp. nov., Traq.—Buckler triangular in general appearance, rather acutely and conspicuously pointed in front, cornua rather prolonged and incurved, orbits large, polygonal tessellation somewhat coarse. Surface ornament not seen.

This is a most striking form, no hitherto described species of *Cephalaspis* having that remarkably pointed anterior contour which indeed reminds us of the front of a Skate. I beg therefore to dedicate the species to Mr. Whiteaves, who has been the first to describe the fishes from Scaumenac and Campbelltown.

ACANTHODIDÆ.

Mr. Smith Woodward has already pointed out that the species named by Whiteaves *Ctenacanthus latispinosus* and *Homacanthus gracilis* are Acanthodian in their nature, and are not distinguishable from those of *Climatius*.[1]

GYRACANTHUS.

A veritable Selachian ichthyodorulite has, however, turned up in the shape of a new species of *Gyracanthus*, to which I apply the name *G. incurvus*. The length of the spine is $2\frac{1}{8}$ inches, but though the point is entire, some of the base has been lost, so that originally it must have been a little longer. It shows an antero-posterior curvature of a very much stronger and more pronounced description than is found in the young forms of any hitherto described species, and this together with the great delicacy of its ornamentation distinguishes it as new. The ornamentation consists of rather fine

[1] Ann. and Mag. Nat. Hist. (6) iv. p. 183.

ridges passing with a very slight obliquity over the side of the spine; this obliquity increases towards the base as well as towards the anterior aspect, where the ridges are also rather coarser than posteriorly. The ridges are plain at the apex, but soon become crenulated, the crenulations being more pronounced on the anterior aspect.

That this species belongs to the genus *Gyracanthus* is fully shown, not merely by the nature of the ornament, but by the obliquity of the posterior area, the prominent edge of which is armed with a row of minute denticles.

Gyracanthus has hitherto not been known to exist below the horizon of the Carboniferous rocks. Its occurrence in the Lower Devonian of Canada is therefore as interesting a fact as the occurrence of *Cephalaspis* in the Upper Devonian of the same country.

VI.—Notes on the Geology of the Gironde, with Especial Reference to the Miocene Beds.

By George F. Harris, F.G.S.

DURING the past summer I had the pleasure of studying the Miocene and Upper Oligocene beds at various places in the Bordelais, mostly under the guidance of the amiable Professor of Geology in the Faculté des Sciences in Bordeaux, Monsieur E. Fallot; and the following notes are mainly intended to give an idea of the present appearance of the classical Miocene sections in that district, and to say something concerning their classification and that of the other Tertiary beds of the Gironde, following the most recent researches on the subject. In doing so, the names of the principal localities rich in fossils will be prominently brought forward (supplemented by a table at the end of the article), chiefly with a view to enable us readily to fix the exact horizons of specimens in museums and private collections in this country.

The Tertiary beds overlie the Upper Cretaceous, and these, the only Secondary beds cropping out in the Department of the Gironde, are found near Villagrains and Landiras. They mostly consist of yellowish compact limestone with flints and the few fossils that have been collected, especially the Echinoderms, indicate that both the Sénonien and Danien divisions are present.

Eocene.

The Lower Eocene nowhere rests on the yellow chalk at its outcrop, but in well-borings, beds probably of this age are met with. M. Benoist believes[1] that a limestone with *Crenaster* and *Orbitoides* in a well at the Chateau of Vigneau is about the age of the Calcaire de Mons of southern Belgium, which latter it might be mentioned is intermediate in age between our Thanet beds and the uppermost Chalk. Above the *Crenaster* limestone, a conglomerate surmounted by clays and lignites appears, and these the same authority regards as the equivalents of the lignites of the Soissonais of the Paris

[1] Journ. d'Hist. Nat. de Bordeaux, 1887.

basin, which are on about the same level as our Woolwich and Reading series. Following on above these in a well-boring in Blaye, sands and sandstones occur containing *Nummulites planulata*, var. (aplatie), believed by M. Benoist to be the equivalents of the Sables de Cuise of the Paris basin, on about the same horizon as the uppermost part of the London Clay and the Lower Bagshot beds (London sands) of the London basin.

It is noteworthy that if M. Benoist's classification is correct, the general succession of the Lower Eocenes of the Gironde is not very different to that of the south of Belgium and northern portions of the Paris basin, except that the equivalents of the Thanet sand are missing in the Bordeaux district. Even the lignitic character of the analogues of the Woolwich and Reading series is persistent.

M. Fallot, however, is of opinion that M. Benoist is rather too sanguine about the evidence obtainable from the well-borings. He regards[1] most of the conclusions as to correlative age as hypothetical, although he admits that just outside the Department, near Saint-Palais (Charente-Inférieure), the equivalents of the Sables de Cuise are found. He raises a question as to whether the *Nummulites* are correctly determined.

There is no doubt whatever that Middle Eocene beds are found in the Gironde. The lower portions termed "Couches à *Nummulites*," mostly sands and sandstones, are found only in well-borings. The lowermost Eocene bed cropping out at the surface is the Calcaire Grossier, and both the upper and the lower divisions of this formation occur with characteristic fossils such as *Strombus ornatus*, *Potamides angulosus*, *P. tricarinatus*, and *Delphinula conica*, at Blaye. The Calcaire Grossier is approximately equivalent to our Bracklesham beds.

Above these come the "Bartonien" series of clays, marls and lacustrine limestones, characterized by the usual *Ostrea cucullaris*, *Limnea longiscata*, *Planorbis rotundatus*, etc. The lower portion of the series corresponds to the "Sables de Beauchamp" (part of the Sables Moyens) of the Paris basin, or in part to our Barton beds; and the upper to the "Calcaire de Saint-Ouen" or our Upper Bagshot sands. The Bartonien beds in the district under discussion are found principally in the Blayais and the Médoc.

The Upper Eocene (French classification) or "Ligurien" crops out at various places in the northern half of the Department, more especially in the Blayais, the Médoc, and near Saint-Vivien. This subdivision of the Tertiaries in the Gironde is known also as the "Calcaire marin de St.-Estèphe." It is specially characterized by *Sismondia occitana*, which occurs in great abundance. M. Benoist has recognized[2] three horizons :—

1. Upper zone with *Clavagella Moulinsi*.
2. Middle zone with Echinoderms.
3. Lower zone with *Miliolites* and *Orbitolites*.

[1] Esquisse Géol. du Dept. de la Gironde (Feuille des Jeunes Naturalistes, xix. an.), 1889, p. 5.

[2] "Desc. des communes de St.-Estèphe et de Vertheuil," p. 12.

The upper zone contains numerous molluscs which serve to fix the correlative age of the deposit. Amongst them may be cited *Rostellaria* (*Rimella*) *fissurella*, *Calyptræa trochiformis*, *Turritella sulcifera* and *Diastoma costellata*. These have a distinctly Calcaire Grossier appearance, but M. Fallot says [1] that the bed being above the *Limnea longiscata* limestone places it rather on the horizon of the Upper than the Middle Eocene of the Paris basin. I cannot help thinking, however, that correlation by means of fresh-water limestones containing long-range species is a rather doubtful proceeding. These local fresh-water beds are liable to occur at various horizons in the Eocene and Oligocene.

At Grave, Bonzac, and other places, clay with *Palæotherium* is classed with the Upper Eocene, but the higher portions of the beds are believed to be the equivalents of the horizon to be next described.

Certain marls and loose sandstones above the *Sismondia* limestone which crop out in the same districts as that bed, are of doubtful age. They are divided into two parts, the upper being characterized by *Anomia girondica*, and the lower by *Ostrea bersonensis*. The upper series at the quarry of Meynieu near Vertheuil contains a fauna having considerable affinities with the Tongrien (Oligocene). They seem to be passage-beds between the Eocene and Oligocene.

Oligocene.

The beds classed under this division of the Tertiaries were, all of them, called Lower Miocene by old authors, and much confusion has thus arisen, though the alteration was in some respects a very good one. I would particularly call attention to the fact that in consequence of this change in nomenclature a great many of the excellently-preserved fossils in our Museums labelled "Dax [2] (Gaas) Miocene," "Bordeaux Miocene," etc., are not in reality Miocene fossils, but Oligocene. Where the precise locality is attached to the specimens, it ought not to be difficult to assign them to their proper age, and even where this information is not given, the colour of the matrix of the bed, together with the correct identification of the species, enables any one familiar with the beds in the field to say definitely, in regard to the majority of the specimens, whether they are Oligocene or Miocene. Further, the particular formation of either division to which they belong could also by this means in most cases be indicated. The recognition of these facts opens up the question whether, in describing species supposed to be new to science, English palæontologists have given that close attention to the so-called Miocene species (really Oligocene) of the Aquitaine basin that they might have done. We are all aware of the tendency of many authors to "create" new species almost solely on the ground that they occur in different, rather widely separated, subdivisions from other species having the closest affinity to them, and which, if they only occurred in one and the same deposit, would be regarded as specifically identical or varietal at most. For instance, suppose

[1] *Op. cit.* p. 8.

[2] Dax is in the Department of the Landes, but seeing that many authors allude to the locality in connexion with Bordeaux Miocenes, I thought it desirable to mention the place.

English Upper Eocene mollusca are being identified, I fancy very few would give more than the most superficial glance at works on fossils called (under the old nomenclature) Miocene, and yet on the transference of portions of these latter to the Lower Oligocene, we are presented with a fauna of the same age as our Headon beds. I was very much struck with the close resemblance of several species of the Oligocene mollusca in the Bordelais with those of the Oligocene beds of the Isle of Wight, and I believe many of them are specifically identical, whilst others certainly ought not to rank higher than "varieties," though the mollusca referred to are now regarded as entirely distinct species. On the present occasion, however, I do not propose to go further into this matter.

The Oligocene beds of the Gironde are divided into two étages, the Tongrien and the Aquitanien.

The *Tongrien* is subdivided into four parts:

1. Lower mollasse of Agenais.
2. *Asterias* limestone.
3. Lacustrine limestone of Castillon.
4. Mollasse of the Fronsadais.

No. 4 is, generally, a greenish sandy clay without fossils. At Fronsac certain beds under this have been called "infra-mollassiques" by MM. Fallot et Croizier.[1] It is difficult to give the precise age of these and of several other beds found on about the same horizon in certain parts of the Department; but according to the views of the former observer, they constitute a passage between the Eocene and Oligocene.

No. 3 is not very persistent in character. In the typical locality it is a white limestone with flints, containing fresh-water mollusca, which seem to indicate that it is approximately of the age of the "Calcaire de Brie" of the Paris basin.

No. 2 is also known as the Bourg or Saint-Macaire limestone, and is the most typically developed Tongrien bed in the district. The lower part, well developed near Libourne, contains *Ostrea cyathula* and *O. longirostris*. The upper or true *Asterias* limestone forms the hills between Roque-de-Tau and Bourg, the high ground bordering the Dordogne, and, generally, the south-eastern and central portion of the Department, and in certain places from Pauillac to Vendais, between the western bank of the Garonne and the sea. Characteristic fossils are *Trochus labarum*, *Natica* (*Ampullina*) *crassatina*, *Pectunculus angusticostatus*, *Delphinula scobina* and *Lucina Delbosi*. The general facies, M. Fallot says,[2] is that of the "Sables de Fontainebleau" of the Paris basin.

No. 1 is a green or yellow clay with calcareous concretions; in some localities the beds are more or less sandy, but interesting on account of the occurrence in them of *Anthracotherium*, *Rhinoceros*, and other mammals.

The higher subdivision of the Oligocene—the Aquitanien—is generally split up into three assises:—

1. Upper.—Grey limestone of Agenais.
2. Middle.—Bazas sandstone, and middle mollasse of Agenais.
3. Lower.—White limestone of Agenais.

The Aquitanien beds crop out principally in the south-east of the

[1] Actes Soc. Lin. de Bordeaux, tome xl. p. 55.

[2] "Esquisse Géol. du Dept. de la Gironde," 1889, p. 10.

Gironde, but also in many river-valleys to the south and west of Bordeaux. The upper and lower Aquitanien have generally a fresh-water facies, whilst the middle is marine; but this does not hold good in the western portions of the area under consideration. As they are traced westwards, the fresh-water beds gradually become more marine in character, and, as might naturally be supposed, it is next to impossible to define the three assises where this is the case; the latter have, therefore, only a local value in the Agenais.

The Aquitanien beds presenting the greatest interest, perhaps, to English palæontologists are those found in the valleys round Saucats and La Brede, about twelve miles south of Bordeaux, for the majority of the Bordelais Oligocene fossils come from thence. The district has been most admirably described by M. Tournouër,[1] and the following useful zones have been established, the oldest, as usual, being placed at the bottom :—

5. Marly lacustrine limestone, with *Helix girondica*, *Limnea girondica* and *Dreissina Brardi*.
4. An argillaceous bed with *Potamides* in one place and a marine bed in another.
3. Lacustrine limestone of Saucats.
2. A loosely compacted sandstone corresponding to the Bazas sandstone, and known to Bordeaux geologists as "roche sableuse jaune."
1. Blue and white clays with *Neritina Ferussaci* (*Nerita picta*).

These form the first (lowest) five zones of what are known as "les couches faluniennes" of that author.

The bed No. 4 at Lariey (about two miles north-east of Saucats) is very fossiliferous, containing many species originally called "Lower Miocene." Under M. Fallot's guidance, I succeeded in obtaining a large number from a few small openings, amongst which may be mentioned *Cyllenina baccata*, var. *minor*, *Proto Basteroti*, *Calyptræa sinensis*, *Chama Brocchi*, *Lucina dentata*, *Terebra* (*Hastula*) *cinerea*, and *Cytherea undata*.

The same horizon is met with under another guise in a road-section on the way to Son, between Lariey and Saucats, but nearer the former place. The locality is sometimes referred to as "Moulin de l'Eglise." In this road-cutting one sees zones 3, 4, and 5. Here zone 4 has changed into a brackish-water fauna chiefly composed of *Potamides*.

Miocene.

This comprises the Middle and Upper Miocene of old authors. Beds of this age occupy the greater portion of the western half of the Gironde; but they are so completely covered by superficial deposits, mostly by the "Sable des Landes," that they are visible at but very few points, situated almost exclusively in river-valleys which have been cut by ordinary river action, down through the "sable" alluded to. The beds are divided into four parts, forming, in upward succession to the Bordelais Aquitanien beds, a further instalment of "les couches faluniennes," and numbered as follows :—

9. Faluns of Salles and Sime, with the mollasse of Martignas.
8. Faluns of Saucats and Cestas.
7. Typical falun of Léognan, and those of Cassagne and Lagus.
6. Mollasse of Léognan, with the lower faluns of Léognan and those of Giraudeau and Peloua.

[1] "Bull. Soc. Géol. de France," 2e ser. tome xix. p. 1039.

These are grouped into étages. Nos. 6 to 8, both inclusive, belong to M. Mayer-Eymar's "Langhien" and No. 9 to the "Helvétien," and although this nomenclature is generally accepted by Bordeaux geologists, M. Fallot points out[1] that it is not strictly applicable to the Miocenes of the Gironde. Neither are the Austrian divisions (1st and 2nd Mediterranean étages). The uppermost division of the Miocenes, the Tortonien of Italian geologists, does not seem to occur in the department.

Langhien.—Above the Aquitanien beds at Léognan, some sandy deposits belonging to No. 6 contain many Echinoderms, having at the base a zone with fish-teeth, etc., notably *Notidanus*, *Lamna*, *Oxyrhina* and *Carcharodon megalodon*. In the valley of Saucats the mollasse of Léognan is represented at Giraudeau, near Moulin de l'Eglise, where the ferruginous-looking falun contains a very rich fauna. At the present time, however, this locality is rather disappointing, no section is to be seen, nothing but a planted field surrounded by woods meets the eye, yet the ground is literally covered with fossil mollusca, amongst which I brought away *Ancillaria glandiformis* (very characteristic of this assise), *Proto cathedralis*, *Voluta rarispina*, and *Pectunculus cor*.

About half-way between Giraudeau and the St.-Morillon railway-station one leaves the main road, and following a rough cart-track to the southward through the vines for about 200 yards, comes across the fossiliferous locality of Peloua. Here again there is no section, but it is one of the classical localities in the Bordeaux Miocenes, having yielded about 400 species of fossils. At the time of my visit, by good fortune, the most interesting part of the ploughed field was not planted with vines; if it had been, we should not have obtained permission to visit the spot, and this remark applies generally to many of the most interesting localities in the Bordelais. As it was, I picked up a large number of corals and mollusca. Amongst the latter were *Ranella tuberosa*, *Tudicla rusticula*, *Strombus Bonelli*, *Melongena cornuta*, *Potamides plicatus* and *Pecten burdigalensis*. The horizon of the Peloua zone is believed to be about the same as that at Giraudeau. M. Fallot pointed out to me the fact that the Peloua fauna contains almost all the species of *Potamides* found at Lariey and Moulin de l'Eglise (bed No. 4 of "les couches faluniennes"), to which places I have already referred, and it possesses other affinities linking it closely to the Oligocene, at the same time the general facies is decidedly Miocene. In the absence of sections, it is not easy to say what are the precise stratigraphical relations between the Miocene and Oligocene of the Bordelais, but the palæontological evidence certainly proves that the passage from the one to the other is very gradual.

Zone No. 7 at Léognan is divided into two parts, the lower being a yellow sand, the higher a blue clay, both of which contain numerous fossils. These beds are also represented in the valley of Saucats, the former at Cassagne, the latter at Moulin de Lagus. The last-mentioned place, very close to the village of Saucats, like

[1] "Esquisse," *op. cit.* p. 15.

| TABLE OF CLASSIFICATION OF THE TERTIARY BEDS OF THE GIRONDE (AFTER FALLOT).[1] | | |

	Middle and middle mollasse of the Valleys .... No. 2			
	Tongrien	*Asterias* Limestone	*Asterias* limestone properly so-called	Hempstead, Bembridge, Osborne, and Headon series.
			Ostrea longirostris, and *O. cyathula* marls	
		Lacustrine Limestone of Castillon and Civrac (Médoc)		
		Mollasse of the Fronsadais		
	Beds of doubtful classification.	"Infra mollassiques" clays and fresh-water limestone of Fronsac		
		Beds with *Anomia*		
Eocene.	Ligurien.	Limestone of Saint-Estèphe with *Sismondia*		Upper Bagshot series.
	Parisien.	Bartonien	Lacustrine limestone of Plassac. Marine beds of St Ysant and Bégadan	Barton series (in part).
			Ostrea cucullaris clays. *Corbula* marls of the Médoc	
		Lutétien	Calcaire grossier of Blaye	Upper limestone with *Echinolampas affinis*	Bracklesham series.
				Lower limestone with *Echinolampas stelliferus*	
			Nummulites beds of borings in the Bordelais	
	Suessonien	*Nummulites planulata* (?) beds of the Blaye borings		London Sands and part of London Clay series.
		Conglomerates and lignitic clays of the Vigneaux boring (?)		Woolwich & Reading series (?)
				Thanet sands (missing in the Gironde).
		Crenaster limestone of the Vigneaux boring (?)		(Calcaire grossier de Mons (?) (Belgium).)

[1] "Esquisse Géol. des Dept. de la Gironde" (1889) p. 23. I have altered M. Fallot's table in certain places, especially in regard to the Lower Eocene beds, this latter being after the views of M. Benoist ("Esquisse Géol. des terr. Tert. S-O de la France, Journ. d'Hist. Nat. de Bordeaux, 1887). See *ante* p. 23.

The table of English equivalents which I have ventured to draw up is necessarily imperfect; in the present state of our knowledge it is impossible to do more than indicate the approximate relationships of the different beds. For example, the uncertain position of the Saint Estèphe limestone and of the "infra mollassiques" clays renders it very difficult to parallel them exactly with English beds; whilst the synonymy and "undescribed species" of the mollusca in both areas cause exact comparisons of the fauna as at present known to be very misleading.

most of the "sections" in the district, is very difficult to find, unless under guidance. Leaving the village and following the course of the stream, which flows through the hamlet, we presently discover the Lagus section in the river banks, and in order to do any work it is necessary to wade in the deep water, and dig into the uneven ledges made by previous observers. The working is about 12 feet in vertical height, being entirely composed of a blue sandy clay. This is another of the classical sections of the district, having furnished many of the "type species" of the Bordeaux Miocenes. The floor of the broadest ledge, containing many deep pools of water, is literally covered over by *Turritella terebralis* in the finest state of preservation, and, altogether, about 200 species of fossils have been found here. Amongst those I brought away may be mentioned *Terebra Basteroti, Dorsanum veneris, Fusus burdigalensis, Tudicla rusticula, Xenophora* (= *Phorus*) *Deshayesi,* and *Proto cathedralis.* A Pteropod, *Vaginella depressa,* is also very common.

On the opposite side of the village the classical section in zone No. 8 is found. This cutting, known as Pont-Porquey, is by the side of the river, and composed of about ten feet (vertically) of light yellow sand. How much longer this section will be open I cannot say, the digging and searching for fossils along the best zone having caused the upper beds to be undermined, part overhanging so much as to be very dangerous to workers beneath. When this falls, almost the whole section will be obliterated. The best-preserved fossils of the Gironde Miocenes come from this opening, the species are mostly very small, but many still retain their original colour-markings, and, like several of the Vienna mollusca of approximately the same period, the best-preserved tints are orange-red and vermilion. The *Potamides* especially are most clearly colour-marked. Some common species are *Terebra* (*Acus*) *fuscata, Terebra plicaria, Cyllenina baccata, Potamides pictus, Donax transversa, Lucina columbella,* and *Oliva* (*Olivancillaria*) *Basteroti.*

Other localities on the same horizon (No. 8) are Gieux and La Coquillière, both near Saucats. Fresh-water beds are occasionally found in this falun.

At two or three other places in the Gironde, passage-beds between the Langhien and Helvétien occur.

Helvétien, No. 9.—In the commune of Martignas along the Jalle, a greyish yellow mollasse, remarkable for Echinoderms (such as *Echinolampas hemisphæricus*) crops out. This bed has been well described by M. Benoist,[1] but the best-known Helvétien bed in the Gironde is the falun of Salles on the banks of the Leyre, containing *Murex turonensis, Voluta Lamberti, Cardita Jouanneti, Corbula striata, Pectunculus pilosus,* etc. Other parts of this assise are seen at Sime and Cazenave. M. Fallot says that the falun of Salles contains many species found in the Tortonien of Baden (Austria).

It is very doubtful whether any Pliocene beds occur in the Gironde. Some geologists have thought that the "Sable des Landes" is, in part, of this age; but this view is not now generally held.

[1] "Actes Soc. Lin. de Bordeaux," t. xxxii. pp. 97, *et seq.*

The only exception, perhaps, to this is the lignitic deposit at Soulac, with *Elephas meridionalis*, which seems to be a remnant of the Upper Pliocene (Arnusien).

The "Sable des Landes" predominates everywhere between the Gironde and Garonne, and the sea. Its exact age, as we have seen, is not very clear, but it is older than the coast alluvium and dunes of the department.

The best centre, perhaps, to study the Bordelais Miocenes is the village of Saucats. Although it is only twelve miles from Bordeaux, this place is not very accessible, and to go to it and return to Bordeaux every day wastes much time. The village inn might afford worse accommodation. There is absolutely nothing to see in regard to sections in the immediate neighbourhood of Bordeaux itself, nearly all the classical Miocene sections being within a few miles of Saucats. Another good centre is Bazas.

In conclusion, I must express my hearty thanks to Professor Fallot for his kindness and assistance rendered during my visit to the Bordelais, and for giving me permission to study the fossils of the Tertiary basin of the south-west of France contained in the splendid private collection of the Faculté des Sciences under his charge.

VII.—Note on an Occurrence of Willemite in a Slag.

By W. Maynard Hutchings, Esq.

CRYSTALLIZED silicate of zinc, Willemite, has frequently been observed, artificially formed, in metallurgical operations, but so far as I am aware no case has been recorded of its crystallizing out from a magma of slag of a different composition, of which the zinc silicate formed only a comparatively small proportion.

Willemite has been observed in crusts of silicate formed in zinc-muffles during the working of zinc-ores. Stelzner and Schulze describe[1] crystals formed in this manner in cavities in the retorts in which they studied the formation of zinc-spinels. I have myself observed the mineral in very perfect rhombohedral crystals, occurring in cavities of firebrick supports of retorts, in such a manner that their formation was evidently due to zinc vapour passing through the material of the retorts and oxidizing in contact with the siliceous material of the firebrick. Ebelmen formed a crystallized zinc silicate by fusion of silica and zinc oxide in boric acid, but this product does not appear to have been proved to be crystallographically Willemite.

The occurrence I wish to record is in a slag produced in large quantity during the smelting of certain lead-dross containing zinc oxide in a small blast-furnace. The resulting slag contains 12—15 per cent. of zinc oxide, the remainder consisting almost wholly of a basic ferrous silicate.

In cavities in the large slag-balls, after solidification, large numbers of slender acicular hexagonal crystals were noticed. They

[1] Jahrbuch für Min. Geologie und Paläontologie, 1881, I.

were at first supposed to be apatite, like the crystals previously observed by me in a slag of somewhat similar nature.[1] Under the microscope, however, they proved to have very high double-refraction, of *positive* character. Chemical examination proved them to consist of silicate of zinc, with a little iron.

These crystals are as much as half an inch in length and of a thickness up to $\frac{1}{75}$ inch. The majority have no definite terminal faces, but many have perfect rhombohedral end-forms. They are pale yellow in colour, and distinctly dichroic, the ordinary ray being the more strongly absorbed. Nearly all the larger ones inclose a central core of dark amorphous matter.

Thin sections of the slag itself show that it consists mainly of olivine (Fayalite), principally in a confusedly crystalline form, but with a fair proportion of definite crystals. There is comparatively little residual amorphous base. Crystals of Willemite, of the same dimensions as those seen free in the cavities, lie in the olivine in all directions, and have been the first to form. The separation parallel to the basal plane is strongly developed, and cross-sections show, in addition to irregular cracks, a well-marked cleavage with intersections of 120°.

Both Fayalite and Willemite contain a large amount of crystals of magnetite. This latter contains a good deal of intercrystallized zinc-spinel, and is not very readily attacked by acid. It may be separated out by decomposing the slag with acid, evaporation, and solution of residual silica in caustic alkali. If the separated crystals are then digested for some time in strong hydrochloric acid, the magnetite proper is dissolved, leaving a residue of green zinc-spinels, mostly as hollow shells, and fragments of octahedra, but also showing some few perfect crystals.

The slag in which these Willemite crystals occurred was produced uninterruptedly during about 10 days' work of the furnace, and during the whole of this time the crystals could be seen in any ball of the slag which was examined. It may be interesting to note that during another run of the same furnace, producing a similar slag, with rather more than less zinc oxide, no Willemite was formed, either in cavities or in the massive slag. All conditions were the same, and the only difference in composition of the slag itself was that, whereas on the former occasion it contained about $1\frac{1}{2}$ per cent. of lead, the percentage of that metal had risen on the latter occasion to 5. Thin sections showed that there was here very much more amorphous, and nearly amorphous base, in which were large numbers of beautiful idiomorphic crystals of Fayalite.

Thus it would appear that a small amount of lead silicate, itself glassy, had the power to cause much of the slag to solidify in the glassy condition, and to prevent entirely the crystallization of the zinc silicate. Observations of this sort, made on slags, may throw a little light on the manner in which the structure and mineralogical composition of rocks may be greatly modified by apparently unimportant amounts of some one constituent.

[1] "Nature," Sept. 15th, 1887.

In this connection I may perhaps be allowed to refer again to the occurrence of apatite in slag, alluded to above. This still remains the only recorded case in which that mineral has been observed to crystallize from an artificial silicate magma, analogous to its occurrence in eruptive rocks. After first noticing it I had opportunity of seeing the slag in question formed almost continuously for many months. It would frequently happen that for days at a time no crystals of apatite could be seen in the cavities, and then again they would reappear in great quantity. Although much attention was given to the subject, nothing could be observed to account for either disappearance or reappearance, no change taking place in composition of the slag, or in conditions of formation and cooling.

Attempts were made by Dr. Cohen, of Owens College, to obtain apatite in small fusions in the laboratory. Pieces of the slag rich in apatite were melted in crucibles; similar fusions were made of mixtures of the constituents of the slag in the proportions shown by analysis, and both were subjected to a prolonged "récuit," as in the experiments of Fouqué and Lévy, but no apatite was ever formed.

The crystals of Fayalite formed in slags so very rich in iron show very strongly developed cleavages. Rosenbusch alludes to the fact that the cleavages are more distinct in olivine containing much iron, and this observation is fully borne out in thin sections such as those above alluded to.

NOTICES OF MEMOIRS.

I.—On the Manufacture of Serpentine in Nature's Workshop. By Major-General C. A. McMahon, F.G.S.[1]

THE rocks from which serpentine is mainly derived by an aqueous process are called peridotites though there are several varieties which receive distinctive names. They are all characterized by the predominance of the mineral peridote or olivine. Some meteorites exhibit a marked affinity with peridotites, containing, like the latter, olivine, rhombic and monoclinic pyroxene, and occasionally some basic felspar. Peridotites are not commonly found on the earth's surface, one reason being that olivine is an unstable mineral that readily absorbs water and passes into serpentine.

General McMahon detailed the various ways by which water finds its way into minerals; namely, by cracks; by planes of cleavage and of "chemical weakness"; and by capillary flow through the interspaces between molecules. In connection with the latter branch of the subject he gave a sketch of the kinetic theory as applied to solids, and of Boscovich's theory which helped to elucidate the kinetic hypothesis; and he stated that whether we accept these theories or not, we must give up the idea that the

[1] Abstract of a Discourse delivered before a Meeting of the Western Microscopic Club, London, on the 4th November, 1889.

molecules of which crystalline bodies are composed are compacted tightly together, like the cells of a honeycomb, without interspaces between them; and he referred to some experiments by Professor Heddle on the absorption of water by granites and greenstones, and to his own observations on the practical porosity of some basic igneous rocks. Allusion was also made to the fact that the application of the undulatory theory to the optical phenomena exhibited by transparent bodies involved the assumption of molecular interspaces.

General McMahon then alluded to the law that governs capillary flow, and mentioned that pressure gauges set up in the Severn tunnel 190 feet from the surface, showed that the actual pressure of the water in the rocks at the tunnel exactly corresponded to the calculated pressure, being about 80lbs. per square inch; a fact that proved that the water permeating the rocks acted in one unbroken head. He then alluded to the experiments of Poiseulle, who had shown that capillary flow was increased by heat; water at 45° Centigrade flowing through capillaries three times faster than water at zero Centigrade.

The capacity of water to hold carbon dioxide and oxygen in solution was next alluded to. Water at 60° is capable of taking up rather more than its own volume of carbon dioxide, and meteoric water contains two cubic inches of oxygen and one cubic inch of carbon dioxide per gallon. As rain-water passes downwards into the earth the percentage of oxygen is reduced and that of carbon dioxide increased. He explained how this fact, as pointed out by Prof. Heddle in a paper read before the Royal Society, Edinburgh, accounted for the ferrous oxide in olivine being removed as carbonate, when rocks were acted on at some depth, but converted into magnetite, or ferric oxide, when subjected to aqueous agencies nearer the surface.

Carbonated water is capable of decomposing the silicate of magnesia, and of carrying off some of the magnesia in the form of carbonate, as proved experimentally by Bischof. Profs. W. E. and R. E. Rogers further showed that digestion in simple water for three days was sufficient to remove an appreciable amount of magnesia from such minerals as hornblende. General McMahon stated that he obtained a similar result by the digestion of powdered olivine in distilled water heated to about 100° F.

The formula for olivine is $2MgO.\ 2FeO,\ SiO_2$, and it was explained in detail how the removal of the ferrous oxide, a portion of the magnesium silicate, and the absorption of water converted olivine into serpentine. The formula for the latter is $3MgO,\ 2SiO_2,\ 2H_2O$.

Taking enstatite and malacolite as types of the rhombic and monoclinic pyroxenes, and tremolite as that of the amphiboles, he explained how the lime was removed and the percentage of magnesia was increased. Whilst olivine, the predominant mineral, was parting with some of its magnesia, the silica set free in the pyroxene by the decomposition of the silicate of lime combined with this surplus magnesia on its exit from the olivine and a gradual conversion of pyroxene into serpentine was the result.

II.—The "Manure" Gravels of Wexford.[1] By Alfred Bell.

SINCE the last report the explorations carried out in the area of the gravels, in Ballybrack, Balscaddin, and Balbriggan Bays, in Larne Lough and the vicinity, and Portrush, have much augmented the material previously accumulated.

The exigencies of building and road-making have practically obliterated the most prolific portion of the drifts in Ballybrack (or Killiney) Bay and the deposit at Portrush, the only traces of the shell-bed at the latter place occurring between the rocky masses on the shore above high-water mark. Fortunately, previous to these operations a quantity of material was obtained by the reporter, and a list of about 120 species will be given in the sequel, wherein a brief notice of the principal deposits will be found, with lists of fossils obtained by the writer and previous observers. The line of research to which an examination of the fossils has led is to the effect (1) that the so-called Lower, Middle, and Upper drifts in Ballybrack Bay have no connection whatever with the equally so-named deposits in the English and Welsh areas, but are a continuation northward of the Cotentin—St. Erth-Wexford sea-bed referred to in the second report, 1888, further traces of this extension obtaining in the glacial clays of the Isle of Man, *Nassa reticosa*, among other Pliocene mollusca, occurring in the northern portion of the island.

Coeval with the Pliocene fauna of Wexford, Ballybrack, and the Isle of Man are numerous species of northern origin, and examination of these suggests a Scandinavian rather than an American or Greenlandic origin—a suggestion intensified by the presence of a true Scandinavian fauna in several parts of the Scottish lowlands from the Clyde to the Forth and the eastern side of Scotland; and it is not perhaps too improbable to suppose that the Pliocene shells obtained by Mr. T. F. Jamieson in Aberdeenshire came by this route rather than from the Suffolk crag-beds. From the absence of the Pliocene fauna northward of the before-quoted localities on the Irish coast and Manxland, the writer is of opinion that the Irish Channel was closed when the strata at these places were being accumulated, and

(2) That the Severn drifts from Worcester northwards into Lancashire are of much later date, not originating till the south of Ireland was separated from the continent. And lastly, that the faunas obtained both in England and Ireland, near Dublin and Wicklow, at elevations of 1000 feet and more, are "remanie" and not in their original habitat.

An examination of the gravelly and shelly sand dredged from the Turbot bank in the Irish Sea has long convinced the writer that the accumulation is in the main of post-glacial age, intermixed with a few recent forms, easily distinguished from the older species by their appearance. The material is very rich in other groups than the molluscan, catalogued already by Mr. Hyndman. Of all these he purposes giving a list.

[1] Third Report read in Section C., Geology, at the Meeting of the British Association, Newcastle-upon-Tyne, 1889.

It may be well to say that the matter first examined was sent to the writer some years back by Mr. E. Waller, who worked with Mr. Hyndman on the mollusca; and, secondly, from a quantity of Mr. Hyndman's own washings, placed at his disposal by Mr. S. A. Stewart, of Belfast.

REVIEWS.

I.—Report on the Geology of the Rainy Lake Region. By Andrew C. Lawson, M.A., Ph.D. Annual Report of the Geological and Natural History Survey of Canada for 1887. Part F.

THE progress of knowledge with reference to the foliated crystalline rocks has been very rapid of late years, and accompanied by incidents that may almost be described as sensational. One such incident was the announcement by Mr. Lawson at the meeting of the International Geological Congress, held in London, that the Laurentian rocks in the neighbourhood of Rainy Lake were intrusive into a series consisting of schists, diabases, felsites, agglomerates, and greywackes.

Up to the time of the announcement of Mr. Lawson's discoveries it had been supposed that the Laurentian rocks were always older than the rocks in contact with them, and the hunters after that geological Will o' th' wisp, the primitive crust of the earth, were beginning to feel tolerably satisfied that they had at last caught the object which had hitherto eluded their grasp. It was seen at once that Mr. Lawson's discoveries reopened the whole Laurentian question, and made it possible if not probable that the so-called Laurentian system was a complex, and that the most characteristic rocks of the system—the gneisses—were plutonic igneous rocks, actually of later date than rocks which have been formed by such agencies as are now in operation at the surface of the earth.

We have in the Memoir before us the details of Mr. Lawson's work, illustrated by an admirable map of the Rainy Lake region, and by photographs of actual junctions. A study of this Memoir will leave no doubt in the mind of any geologist that Mr. Lawson has fully established his main point, which is this—that over an area of several thousand square miles the gneisses hitherto[1] regarded as Laurentian have consolidated as such from a plastic magma long after the formation of the rocks which encircle them. As this point is one of great importance we will give a somewhat detailed account of Mr. Lawson's work.

The rocks into which the Laurentian is intrusive are divided by the author into two series—the Coutchiching and the Keewatin. The earlier or Coutchiching series consists mainly of mica-schists and granulitic gneisses. The dominant constituents of the mica-schists are granulitic quartz and biotite. The gneisses differ from

[1] The term Laurentian is still retained for these rocks in this Memoir.

the mica-schists principally in containing felspar. The structure of both rocks is the same. The original rocks are supposed by the author to have been of sedimentary origin.

The Keewatin series is much more variable in character. It includes diabases, hornblende-schists, soft fissile green schists, conglomerates, sericite schists, felsitic schists (altered quartz-porphyries) greywackes and volcanic tuffs.

The "bedded traps or greenstones" give the character to this series. They have suffered more or less alteration (*a*) by metasomatic processes, (*b*) by dynamic action. Those which have been affected by the first set of processes only preserve the original structure so as to leave no doubt as to the original characters of the rocks. Some have the ophitic structure of diabases, others the granular structure of gabbros. Those which have suffered dynamic metamorphism have lost their original structure to a greater or less extent, and taken on that of a schistose or foliated rock. The constituents of these more or less altered basic igneous rocks are felspar, pyroxene, fibrous and compact hornblende, titaniferous iron ore, apatite, leucoxene, zoisite, epidote, chlorite, calcite, and quartz. The rocks are described by the author under such names as uralitic and saussuritic gabbro, uralitic diabase and porphyritic diabase. It is evident from the detailed descriptions with which the Memoir abounds that the rocks are similar to varieties of greenstone occurring in the West of England.

The hornblende-schists are regarded by the author as being in part altered massive rocks, and in part altered pyroclastic rocks of basic composition. The felspathic varieties approach diorites in structure and composition. Dynamic action has certainly determined the structure of these rocks, but it has operated before the final stages of recrystallization were complete, for the individual constituents do not show any of those effects of pressure which are so common in the schistose diabases.

The soft green fissile schists are usually bedded and are probably metamorphosed pyroclastic rocks.

The matrix of the conglomerates is a dark green chloritic or hornblendic schist. The pebbles are often well-rounded and reach as much as a foot in diameter. They consist of saccharoidal quartz, felsite, quartz-porphyry and granite. It will be noted that pebbles of Laurentian gneiss are conspicuous by their absence.

The sericitic and felsitic schists are merely altered quartz-porphyries. They are associated with acid volcanic tuffs and agglomerates.

In addition to the volcanic rocks which form the bulk of the series there are grits or greywackes, which consist, for the most part, of ordinary sedimentary material.

Owing to the enormous jamming together which the rocks have undergone it is not possible to estimate the thickness of the Keewatin series. It must, however, have amounted to many thousands of feet. Their general disposition is that of a sharply folded trough, sinking down into the gneiss which flanks it on either side. The horn-

blende-schists and diabases form the lower, and the felsites and felsitic schists the upper portions of the series, according to the author.

Now the Laurentian rocks of the district under consideration occur in "central circular or oval areas." Each area is isolated at the surface from its neighbours by a belt of Keewatin or Coutchiching rocks. In most cases the breadth of this belt is very small in comparison with the diameter of the Laurentian areas. The author has traced out the boundaries of three of these areas, which he names the Obabicon, the Sabaskong, and the Stanjikoming areas respectively. He has also partially mapped out two other large areas which lie to the N. and N.E. of the Stanjikoming area. To give some idea of the scale on which the phenomena are developed, we may mention that the Stanjikoming area measures thirty-two miles from N. to S. and forty-six from E. to W. It is separated from the Sabaskong area on the N.W. by a belt of Keewatin rocks about three miles in width, and from the Lake Harris area on the N. by a belt of the same rocks about $4\frac{1}{2}$ miles in width.

The contact of the two groups of rocks is well exposed at many points, especially on the shores of the numerous lakes. It is everywhere the same, and leaves no doubt as to the relative ages of the rocks. The gneisses are intrusive. They send out apophyses into the adjacent rocks, and contain included fragments, often in immense numbers. The apophyses are sometimes in the form of sheets running parallel to the schistosity or bedding of the surrounding rocks; sometimes in the form of veins or dykes cutting across the bedding. The rocks in contact with the Laurentian are not always the same; sometimes they are the hornblende-schists which form the basal members of the Keewatin series; sometimes the felsitic rocks which constitute the higher members of the same series, and sometimes the biotite-schists of the Coutchiching series.

The Laurentian rocks are divided by the author into two principal groups depending on the amount of quartz which they contain, and termed respectively syenitic and granitic gneisses. Thus we have hornblende-syenite gneiss, biotite-syenite gneiss, hornblende-granite gneiss, and quartzose biotite gneiss. The constituents are orthoclase, microcline, plagioclase, quartz, biotite, pyroxene, hornblende, sphene, epidote, zircon, magnetite. The hornblende frequently contains cores of pyroxene, and the author is inclined to regard the whole of it as paramorphic after pyroxene. The general microscopic structure is granitic, and crush phenomena are as a rule entirely absent. Foliation is generally well marked, but massive areas may sometimes be observed. The different varieties shade into each other.

In the Stanjikoming area the syenitic gneisses occur on the borders; the quartzose biotite-gneisses in the central area.

One striking feature which is brought out by an extended survey of the Laurentian areas is the concentric character of the foliation. At the margins the strike of the foliation is parallel to the

junction; in the interior it is concentric with reference to one or more centres.

The author has paid special attention to the phenomena of the inclusions. These inclusions are found, not only near the margins of the Laurentian areas, but also in the central portions. They vary in size from that of one's fist to that of a house and even larger. Near the junction a definite connection between the inclusions and the surrounding rocks may be traced. Thus, at the contact with hornblende-schist, the inclusions consist of hornblende-schist, and at the contact with the Coutchiching series they consist of rocks derived from that series.

The inclusions are sometimes angular and sharply separated from the gneiss, at other times they are lenticular and blend more or less gradually with the surrounding rock. The elongated inclusions are arranged with their longer axes parallel to the general foliation. All the facts go to show that the parallel arrangement of the inclusions and the foliation of the gneiss are fluxion phenomena. Certain banded gneisses are regarded by the author as due to a stretching of an intimate mixture of inclusions with the gneissic magma. The memoir is illustrated by photographs of portions of the gneiss which are rich in inclusions, and one of these (plate vi.) bears a most striking resemblance to Fig. 2, Plate XIV.[1] Geol. Mag. Dec. III. Vol IV. 1887.

In addition to the points above referred to, the Memoir contains much interesting matter. Thus it treats of the relation between topography and geological structure, the petrographical characters of numerous intrusive granites, the distribution and character of certain later basic dykes, and the glacial phenomena of the district.

As regards the origin of the Laurentian rocks the author propounds the theory that they represent the fused floor on which the Coutchiching and Keewatin rocks were deposited, and to a certain extent also of fused portions of these rocks. He insists, however, strongly on the point that whatever may have been the origin of the magma, the minerals of which the Laurentian rocks are composed, and the structures which these rocks possess, owe their origin to causes operating after the formation and folding of the rocks with which they are in contact.

In speaking of the topography of the Laurentian areas he says "it is remarkably flat and devoid of prominent elevations, although the surface in detail is extremely uneven and hummocky or mammillated. It presents for the most part the glaciated surface of the rocks either quite bare or covered only by forests and forest loam. The plateau abounds in lakes, which lie in rocky basins." This description will be thoroughly appreciated by all those who are acquainted with the Archæan topography of the N.W. of Scotland.

J. J. H. T.

[1] This plate illustrates a paper by the reviewer "On the Origin of Certain Banded Gneisses."

II.—Einige Bemerkungen ueber die Jura-Ablagerungen des Himalaya und Mittelasiens. Von S. Nikitin. Neues Jahrbuch für Mineralogie, etc., 1889, Bd. II. pp. 116–145.

Remarks on the Jurassic Strata of the Himalaya and Middle-Asia. By Prof. Nikitin of St. Petersburg.

THE principal development of Jurassic beds in the Himalaya is on the north-eastern slopes of the southern crystalline chain in the neighbourhood of Spiti and Niti, where, resting on strata referred to the Rhætic and Lias, are the well-marked dark crumbling shales known as the "Spiti shales." These shales are filled with phosphatic concretions, which have yielded a rich fauna, principally of Ammonites, which have been studied and described by Oppel, H. F. Blanford, Stoliczka, Waagen, and Neumayr. Very different opinions have been expressed by these authors as to the relations of the Ammonites to those in the Jurassic rocks of Europe and of Cutch, and consequently as to the relative geological horizon of the rocks themselves; but they have been generally reckoned as of the age of the Kelloway and Oxford Clays, and supposed, more particularly by Neumayr, to be related to those of the Russian and Polar Jura. Prof. Nikitin has lately studied the two most important collections from the Himalaya; that of Schlagintweit at Munich, and of Strachey, in the British Museum, and in this paper he discusses the characters of the Ammonites and other fossils, and gives reasons for regarding them as belonging to a younger horizon than hitherto supposed. The following are the conclusions to which he has arrived: (1) The fauna of the Spiti shales stand nearest to that of the Tithon and Kimmeridge of Western Europe. Most of the Ammonites which up to now have been considered as Kelloway and older forms represent much younger types. (3) The differences between the fauna of Spiti and that of Cutch may be easily explained on the supposition that the fossil-bearing beds in the two regions do not represent synchronic horizons. (4) The Himalayan Jura shows a far more significant relationship to the Tithon of Southern Europe than to any Russian Mesozoic formation. (5) The fauna of the Russian Jura on the other hand is more intimately united to that of Cutch than to that of the Himalayan Jura. (6) The assumed geological and geographical connection of the Himalayan and Indian Jura with the Russian Jurassic ocean, through the supposed Tarim basin, the Altai region, and the great polar ocean, is as yet by no means proved. On the other hand, there are many indications in favour of the connection having taken place through the Amour region, Bokhara, Afghan Turkestan, Khorasan, and the Aral-Caspian depression.

III.—Fossil Fishes from the Devonian of Belgium.

"Recherches sur les Poissons des Terrains Paléozoiques de Belgique." By Maximin Lohest. Ann. Soc. géol. Belg., vol. xv. (1888), Mémoires, pp. 112–196, pls. ii.–xi.

THE remains of fishes discovered in the Devonian formation of Belgium are all of a very fragmentary character, consisting chiefly of detached teeth, portions of bones, and isolated scales;

but their determination is interesting on account of their intimate association with truly marine fossils. Until the appearance of the present work only four specimens had been critically examined and described (*Holoptychius Omaliusi*, *Palædaphus insignis*, *Palædaphus devoniensis* and *Byssacanthus Gosseleti*); and palæichthyologists are indebted to M. Lohest for the care and perseverance with which he has collected, examined, compared, and described all available material.

A brief introduction summarizing the present state of knowledge of the Belgian Devonian fish-fauna is followed by the systematic and descriptive part, which occupies fifty pages, and is illustrated by eleven plates. Eight genera and fourteen species are determined, and most of the descriptions are accompanied with good figures drawn by the author. Two forms of teeth from Strud are assigned to *Dendrodus*, the one believed to be identical with certain gently curved teeth commonly associated with *D. sigmoides* and now named *D. Traquairi*, the other regarded as hitherto unknown and named *D. Briarti*. *Lamnodus* is accepted as a sub-genus of *Dendrodus*, and an imperfect tooth from the Upper Famennian of Liège is described as *L. minor*, sp. nov.; the genus *Cricodus* receives a doubtful portion of dentary, named *Cricodus*? *Agassizi*, sp. nov.; and then follows a long section upon *Holoptychius* and its Belgian representatives. M. Lohest has studied the fine specimens in the British Museum, besides others at Edinburgh, and treats of the squamation, especially, in considerable detail. As the result of his researches, he recognizes great variation in the scales of different parts of the body, but considers that detached examples are usually specifically determinable when their outline is distinct; for the scales of corresponding parts in the various species are almost identical in shape and proportions, only differing in thickness and the arrangement of the external ornamentation. Some isolated bones of the genus are first noticed, and then follows a section upon the supposed teeth of *Holoptychius*, which appear to be identical with so-called *Lamnodus* previously described. The typical *H. nobilissimus* is regarded as not certainly met with in Belgium, and the author considers that both Agassiz and the British Museum include under this species some scales of forms that are truly distinct. To us, however, it appears that the scales now named *H. Dewalquei* can be so closely paralleled by examples found in close association with the true *H. nobilissimus* of Clashbennie that there is no justification for their specific separation. Several fine specimens of these scales are figured; and an equally good series of very thin scales, exhibiting a nearly similar ornament, is described and figured as *H. inflexus*, sp. nov. Other scales are identified with the well-known Scottish species, *H. giganteus* and *H. Flemingi*. A brief discussion of *Glyptolepis* results in the conclusion that its scales only differ from those of *Holoptychius* in their comparative tenuity; and some small specimens from Strud are assigned to *G. Benedeni*, sp. nov., and *G. radians*, sp. nov.

After the description of the "Cyclodipterines," the arrangement

of the teeth in the mandible of the several genera is discussed, and it is concluded that here may be found diagnostic generic characters. We venture, however, to think that the differences in the illustrative diagrams are due merely to their being based upon imperfect evidence; and, so far as dental arrangement is concerned, there seems to be no essential difference between the several genera under comparison. When the large teeth are undergoing replacement, the new one is always for a time placed by the side of the old one as indicated in the diagram of "*Lamnodus*"; while it seems most probable (as first suggested by Traquair) that "*Bothriolepis favosus*" is truly referable to *Cricodus*, thus disproving the diagram assigned to the mandible of that genus.

A few ornamented small rhomboidal scales, from Strud and Modave, M. Lohest ascribes to the *Glyptolæmus Kinnairdi* of Dura Den: and several typical, though imperfect, scales of *Phyllolepis* are named *P. undulatus*, sp. nov., and *P. Corneti*, sp. nov. Other scales, very suggestive of *Phyllolepis*, are also described, and on account of their pentagonal outline are believed to indicate a distinct new genus, *Pentagonolepis*, of which the type-species is termed *P. Koninckii*. The characters of the scales lead M. Lohest to regard this genus as one of the Lepidosteoid Ganoids; but all known facts concerning the evolution of the fishes render such a determination most improbable.

The fossil fishes thus enumerated obviously indicate an Upper Old Red Sandstone fauna; and one of the formations yielding them—the "schistes d'Evieux"—is regarded as apparently intermediate in age between the well-known sandstones of Elgin and Dura Den. Lists of species are given; and there is a long, and somewhat inconclusive, discussion as to whether the fishes lived in fresh- or salt-water. Other general considerations, both geological and palæontological, are also treated in the final section of the memoir; and the physical geologist, equally with the ichthyologist, will find several items of interest. A. S. W.

IV.—Upper Cretaceous Fish-remains from Manitoba.

"Contributions to Canadian Palæontology," vol. i. pt. ii. (Geol. Surv. Canada, 1889), pp. 191–196, pl. 26, figs. 5–9. By J. F. Whiteaves, F.G.S.

THE known range of three typical genera of Upper Cretaceous fishes is extended by the recent discovery, in the Niobrara Beds of Manitoba, of some fragmentary, though interesting, remains described by Mr. Whiteaves. A small dental crown of *Ptychodus* is doubtfully determined as new and named *P. parvulus*; but its dwarfed dimensions and comparative narrowness may possibly be explained by its pertaining to the median series of the upper jaw. Two teeth of *Lamna* described as *L. manitobensis*, sp. nov., are very closely related to *Lamna macrorhiza*, and perhaps only a variety of the latter. A small slab of shale exhibits portions of jaws and teeth of *Enchodus*, identified with the Niobrara form (*E. Shumardi*) already discovered in Nebraska; but, as shown by skulls in the British

Museum (Proc. Geol. Assoc. vol. x. p. 315, pl. i. figs. 5, 6), the bone named maxilla is truly the premaxilla, while the so-called premaxillary tooth pertains to the palatine element. Numerous scales of *Cladocyclus* not only add this genus to the list from Manitoba, but likewise appear to be referable to a species known from Nebraska, namely, *C. occidentalis*, Leidy. A. S. W.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—November 20, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.

The Secretary announced that a series of specimens from the line and the neighbourhood of the Main Reef, East and West of Johannesburg, Witwatersrand Gold Fields, had been presented to the Museum by Dr. H. Exton, F.G.S., and a letter from that gentleman in explanation of them was read. In this Dr. Exton stated that all but one of the mines represented were on the main reef of the district, which has a general direction east and west, its dip varying generally from 45° to 80°. South of the main reef and parallel to it at a distance of 15–20 feet is a narrow reef known to the miners as the "south leader," and generally much richer than the main reef. The gold-bearing deposits consist of conglomerates, specimens of which, and of a purplish-red rock which forms a jagged ridge at some distance north of and parallel to the so-called reef, were contained in the collection.

1. "On the Occurrence of the Striped Hyæna in the Tertiary of the Val d'Arno." By R. Lydekker, Esq., B.A., F.G.S.

A portion of the left maxilla of a Hyæna, in the British Museum, containing the entire carnassial, the hinder half of the third premolar, and traces of the inner extremity of a molar, was referred by the author in 1885 to *H. striata*, and provisionally regarded as of Pleistocene age, but subsequently concluded to have been of Upper Pliocene age. The author has also referred a right upper carnassial of a Hyæna from the Red Crag to the same species, on the supposition that Prof. Gaudry's reference of *H. arvernensis* to *H. striata* was correct. In the present case, Dr. Weithofer has concluded that *H. arvernensis* is entitled to rank as a valid species, and has accepted the author's determination of the Red-Crag form, thereby implying that the identification of the latter with *H. arvernensis* was erroneous. Dr. Weithofer also states that all the specimens from the Pliocene of the Val d'Arno which have come under his notice are more nearly allied to the Crocutine group.

In the present paper, measurements of the recent, Red Crag, and Val d'Arno specimens referred by the author to *H. striata* were given, and the differences shown to be within the limits of individual variation, whilst the actual contour of the teeth corresponded, leading the author to maintain the correctness of his original determination.

After comparison of the British Museum specimen with the upper

jaw of Hyænas from the Val d'Arno, figured by Dr. Weithofer, it was shown that the former specimen was distinct from *H. robusta* (which latter is allied to *H. felina* of the Siwalik Hills), whilst a nearer resemblance, though with well-marked specific difference, was made out with *H. topariensis*, which was in turn observed to be closely allied to, if not identical with, *H. Perrieri*.

It was observed that *H. arvernensis* could be with difficulty distinguished from *H. brunnea*, and that both of these were nearer to *H. striata* than to *H. crocuta*, whilst *H. Perrieri* appeared to connect them with the latter.

2. "The Catastrophe of Kantzorik, Armenia." By Mons. F. M. Corpi. Communicated by W. H. Hudleston, Esq., M.A., F.R.S.

The village is 60 kil. from Erzeroum, and 1600 mètres above sea-level. Subterranean noises and the failure of the springs had given warning, and on the 2nd of August, 1889, part of the "Eastern mountain" burst open, when the village, with 136 of its inhabitants, was buried in a muddy mass.

The author described the district as formed of Triassic, Jurassic, and Cretaceous strata, subsequently broken up and torn by granitic, trachytic, and basaltic rocks, which overlie or underlie the Secondary rocks, according to the nature of the dislocation.

The flow was found to have a length from east to west of 7–8 kil., with a width ranging from 100 to 300 mètres, and the contents were estimated at 50,000,000 cubic mètres. It appeared as a mass of blue-grey marly mud, which, after the escape of the gases, solidified at the top; the inequalities projected to the extent of 10 mètres. The site of the village was marked by an elevation of the muddy mass, some of the débris of the houses having been carried forward. The lower part of the flow was still in a state of motion, and carried forward balls of marly matter.

It was difficult to approach the source of this flow on account of the crevasses in the side of the mountain. An enormous breach served as the orifice for the issue of the mud, which emitted, it was said, a strong odour. The violent projection of this marly liquid and "incandescent" (?) mass had carried away a considerable portion of the flanks of the mountain, whose débris might be recognized on the surface of the flow by the difference of colour. Great falls were still taking place, throwing up a fine powder which rose into the air like bands of smoke. There were also fissures and depressions of the ground at other localities in the neighbourhood.

3 "On a new Genus of Siliceous Sponges from the Lower Calcareous Grit of Yorkshire." By Dr. G. J. Hinde, F.G.S.

The author referred, in the first instance, to the discussion as to the nature of certain renuline bodies occurring in the Corallian of Yorkshire and elsewhere. Although regarded of late years as the globate spicules of a siliceous sponge, the apparent absence of acerate and forked spicules in association therewith has always presented a difficulty. Recently the author has recognized in specimens from

Scarborough certain siliceous sponges which seem to be formed entirely of globates. In outward appearance the sponge is upright, and palmate or fan-shaped, the largest being 140 millim. in height. The wall is 14 millim. thick, and consists of plates which anastomose so as to form a labyrinthine structure, and are perforated regularly by oval slits. The laminated walls are composed entirely of small reniform spicules (globates), well seen where secondary crystallization has not fused them together. The globates, like those of *Geodia*, are built up of fibres radiating from the centre, and terminating on the outer surface in nodose ends, which causes a spotted appearance.

The exceptional character of these sponges consists in their having the siliceous skeleton composed entirely of globates. The nearest living form is *Placospongia*, in which both the axis and the dermal crust are formed of globates with an interspace built up of numerous pin-like spicules. Assuming the absence of pin-like spicules in the Scarborough fossil, the differences are more than generic. The name *Renulina*, given by Blake to the globates, having been preoccupied, the author proposed that of *Rhaxella* for the genus, and described the sponge from the Lower Calcareous Grit as *R. perforata*, sp.n.

II.—Dec. 4, 1889.—W. T. Blanford, LL.D., F.R.S., President, in the Chair.—The following communications were read:—

1. "On Remains of Small Sauropodous Dinosaurs from the Wealden." By R. Lydekker, Esq., B.A., F.G.S.

The author first noticed some teeth from the Wealden of Sussex and the Isle of Wight, provisionally referred by Mantell, and subsequently by Sir R. Owen, to *Hylæosaurus*, which he had made the type of a species of *Pleurocœlus*. He then described the imperfect centrum of a dorsal vertebra from the Wealden of Cuckfield, preserved in the British Museum, and a somewhat larger imperfect vertebra obtained from the Wealden of Brook, Isle of Wight.

In the absence of any evidence in favour of a contrary view, he proposed provisionally to refer the vertebra to *Pleurocœlus valdensis*, a name which he had given to the form represented by the teeth in a paper published in the Geological Magazine for the current year. He stated that they afforded absolutely conclusive evidence of the occurrence in the English Wealden of a diminutive Sauropodous Dinosaur, which was the contemporary of the huge *Hoplosaurus* and the still more gigantic *Pelorosaurus*, and that they also served to increase the evidence as to the similarity of the Dinosaurian fauna of the Upper Jurassic of North America to that of the Upper Jurassic and Lower Cretaceous of Europe.

2. "On a Peculiar Horn-like Dinosaurian Bone from the Wealden." By R. Lydekker, Esq., B.A., F.G.S.

Among a series of vertebrate remains sent from the Dorsetshire County Museum to the British Museum, there is an imperfect, stout, short, cone-like bone from the Wealden of Brook, Isle of Wight. It appears to present a close resemblance to the horn-cores of the Dinosaur described by Prof. Marsh as *Ceratops*.

The author did not regard the specimen as affording conclusive

evidence of the existence in the Wealden of a large Dinosaur furnished with horn-like projections on the skull like those of the American *Ceratops*, but suggested that such might really prove to be its true nature.

3. "The Igneous Constituents of the Triassic Breccias and Conglomerates of South Devon." By R. N. Worth, Esq., F.G.S.

During the investigation several hundred fragments were examined, the largest occurring at Teignmouth, between which place and Dawlish the breccias are most varied in composition, and contained the greatest proportion of granitoid rocks. The igneous fragments were thus divided:—I. Granites; II. Felsite group: *a*, non-schorlaceous. *b*, schorlaceous; III. Andesitic group: IV. Miscellaneous. Of these, including in all 76 varieties, I., II. *b*, and IV. are plainly of Dartmoor origin in gross, the schorlaceous and contact-altered rocks having belonged to the outer or to an upper zone; III. can for the most part be identified with the *in-situ* "felspathic traps" of the neighbourhood. The non-schorlaceous division of II. differs but little from Dartmoor elvans; some may have been surface-portions of felsitic dykes, or even fragments of felsitic lavas. The igneous fragments of the breccias, as a rule, are not much altered structurally; they are of local origin.

The large blocks indicate the vicinity of high land abutting on a shore-line. Of this high land Dartmoor is a relic. The transporting power of water was perhaps supplemented by a glacial climate and volcanic activity. De la Beche considered that igneous action accompanied the earliest "red-rock" deposits. The "felspathic traps" are known to be both antecedent to and contemporaneous with the breccias, and there is evidence which points to their being comprised within the period of igneous activity represented by the Dartmoor elvans. The author says that there is a preponderance of volcanic over plutonic igneous rocks, and thinks that the existing remnants of "felspathic traps" are not sufficient to supply the quantity. He suggests that they must have come from an upper portion of Dartmoor.

In conclusion, the author considered that he has shown that the igneous materials are of local origin, and that they consist of granites, felsites, and volcanic types, ranging from andesites to basalts; that the few igneous fragments not hitherto assigned to *in-situ* rocks are yet of a similar character; that the conditions under which the "felspathic traps" occur *in situ* lead to the inference that they are volcanic phenomena which probably represent the final phase of the igneous activity of the Dartmoor region. Lastly, he expresses his opinion that the elevation of Dartmoor and the associated igneous phenomena took place at a period not earlier than the Permian.

4. "Notes on the Glaciation of Parts of the Valleys of the Jhelam and Sind Rivers in the Himalaya Mountains of Kashmir." By Capt. A. W. Stiffe, F.G.S.

After referring to the previous writings of Messrs. Lydekker, Theobald, and Wynne, and Col. Godwin-Austen, the author gave an account of his observations made during a visit to Kashmir in 1885,

which appeared to him to indicate signs of former glaciation on a most enormous scale.

A transverse valley from the south joins the Sind valley at the plain of Sonamurg, and contains glaciers on its west side. These, the author stated, filled the valley at no remote period, and extended across the main Sind valley, where horse-shoe-shaped moraines, many hundred feet high, occurred, and dammed the river, forming a lake of which the Sonamurg plain was the result. The mountains which originated the above glaciers were described as being cut through by the Sind river, and the rocks of the gorge were observed to be striated, whilst rocks with a moutonnée appearance extended to a height of about 2000 feet.

The whole of the Sind valley was stated to be characterized by a succession of moraines through which the river had cut gorges, whilst the hill-sides were seen to be comparatively rounded to heights of 2000 feet or more.

The author had also formed the opinion that at Bâramulla the barrier of a former lake occupying the Kashmir valley was partly morainic, before reading Prof. Leith Adams's view of the glacial origin of some of the gravels of this point.

The whole valley of the Jhelam from this point to Mozufferabad showed extensive glacial deposits, which had been modified by denudation and by the superposition of detrital fans, widely different in character from the glacial deposits. Below Rampoor the valley was thickly strewn with enormous granite blocks resting upon gneiss, and the author believed that they had been transported by ice.

In conclusion, it was noted that the existing torrential stream had further excavated the valley since Glacial times and, in places, to a considerable depth.

OBITUARY.

JOHN BALL, F.R.S., F.L.S., M.R.I.A., &c.

BORN 20TH AUGUST, 1818; DIED 21ST OCTOBER, 1889.

THE sudden death of Mr. John Ball has removed from amongst us a man whose name will be remembered with veneration so long as Alpine geology and botany and mountaineering pursuits retain any of their present interest. As the eldest son of a distinguished lawyer—the Rt. Hon. Nicholas Ball, Attorney-General for Ireland, and subsequently Judge of the Court of Common Pleas—Mr. Ball was naturally destined for the legal profession, and after a brilliant career at Cambridge, he was called to the Irish bar in 1843. He however soon turned his attention from law to politics, and served for some years as Assistant Poor Law Commissioner for Ireland, a post which he resigned on his election in 1852 as Member for Carlow. His Parliamentary career, though brief, was distinguished. The statesmanlike foresight that led him then to advocate the principle of tenants' compensation for disturbance, and the courage

with which he sacrificed his Irish popularity by his defence of the extension of the Income-tax to Ireland, won for him the confidence of the leaders of his party, and led to his appointment in 1855 as Under-Secretary for the Colonies in Palmerston's first administration. But Mr. Ball's defeat at Limerick in 1858 induced him to abandon politics for science.

It was about this time that the Alpine Club was started, and though he was not one of its original founders, Mr. Ball's thorough knowledge of the Alps, and his brilliant exploits there, led to his election as its first President. It is almost impossible now to realize the difficulties with which Mr. Ball had to contend in his early Alpine explorations. The race of skilled mountaineers who now do most of the work of an ascent was not then in existence; though a local guide was indispensable, he usually hindered instead of helping, and was a positive danger on snow or ice; thus in Mr. Ball's ever-memorable passage of the Schwarzthor in 1845, the whole of the difficult work among the seracs of the Schwarz glacier devolved on him; or, again, in the first ascent of the Pelmo, the guide was left behind, too frightened to proceed, while Mr. Ball fought his way to the summit alone.

But it is probably not as a climber that Mr. Ball will be best remembered; others coming after him have reaped the rewards of his labours, and with a better race of guides have gained a wider popular renown by the ascent of better known peaks, or of those around which some striking tragedy has thrown the halo of romance. But while Mr. Ball climbed "he used his head as well as his heels," to quote an old saying of his, and he always studied the botany and geology of the districts he traversed. The former was his favourite science, and as every one knows who has used his Guide, he was as familiar with the local plants as with the local passes. In working out his well-known theory of the origin of the Alpine flora,[1] he made numerous visits to the Pyrenees and the Balkans, and others to the Andes and the Atlas; a lengthy list of memoirs and papers testifies to the ardour of his botanical studies, while some of his results are of as much interest to geologists as botanists. In the controversies over the theories of glacier motion and the glacial origin of lake-basins, Mr. Ball's intimate acquaintance with the Alpine glaciers gave his utterances[2] exceptional weight; his paper on "Soundings Executed in the Lake of Como"[3] seems to have settled the question as far as that lake is concerned. His papers on glacier motion are no less marked by the trenchant criticisms of the theories of Moseley and Croll than by the clearness with which he recognized the fundamental differences between glacier and lake ice.

Though others may have made more striking first ascents, or have left a deeper mark in Alpine geology, there seems to be no question that in his knowledge of Alpine topography, Mr. Ball stood absolutely without a rival. Mr. Ball knew the Alps as no other man ever knew them. His great "Alpine Guide"[4] has rendered invaluable service to all subsequent work on the geography of the Alps. It is not till one has tested this work in some unfrequented region, and compared it with other guide books of the same period, that one can realize with what marvellous instinct its author had seized all the salient features in the district. It is hoped that a new and revised edition of this Guide will be prepared by the Alpine Club, as to give Mr. Ball's greatest work a new lease of usefulness would be the most appropriate memorial to one of the earliest of Alpine explorers and the greatest of scientific mountaineers.

J. W. G.

[1] "On the Origin of the Flora of the European Alps," Proc. Geogr. Soc. new ser. vol. i. 1879, pp. 564-88.

[2] "On the Formation of Alpine Valleys and Alpine Lakes," Phil. Mag. vol. xxv. 1863, pp. 81-103. "On the Formation of Alpine Lakes," Phil. Mag. vol. xxvi. 1863, pp. 489-502. "On the Cause of the Descent of Glaciers," Phil. Mag. vol. xl. 1870, pp. 1-10. "On the Cause of the Motion of Glaciers," Phil. Mag. vol. xli. 1871, pp. 81-87.

[3] GEOL. MAG. Vol. VIII. 1871, pp. 359-63.

[4] Western Alps, 1863; Central Alps, 1864; Eastern Alps, 1868.